STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

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STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

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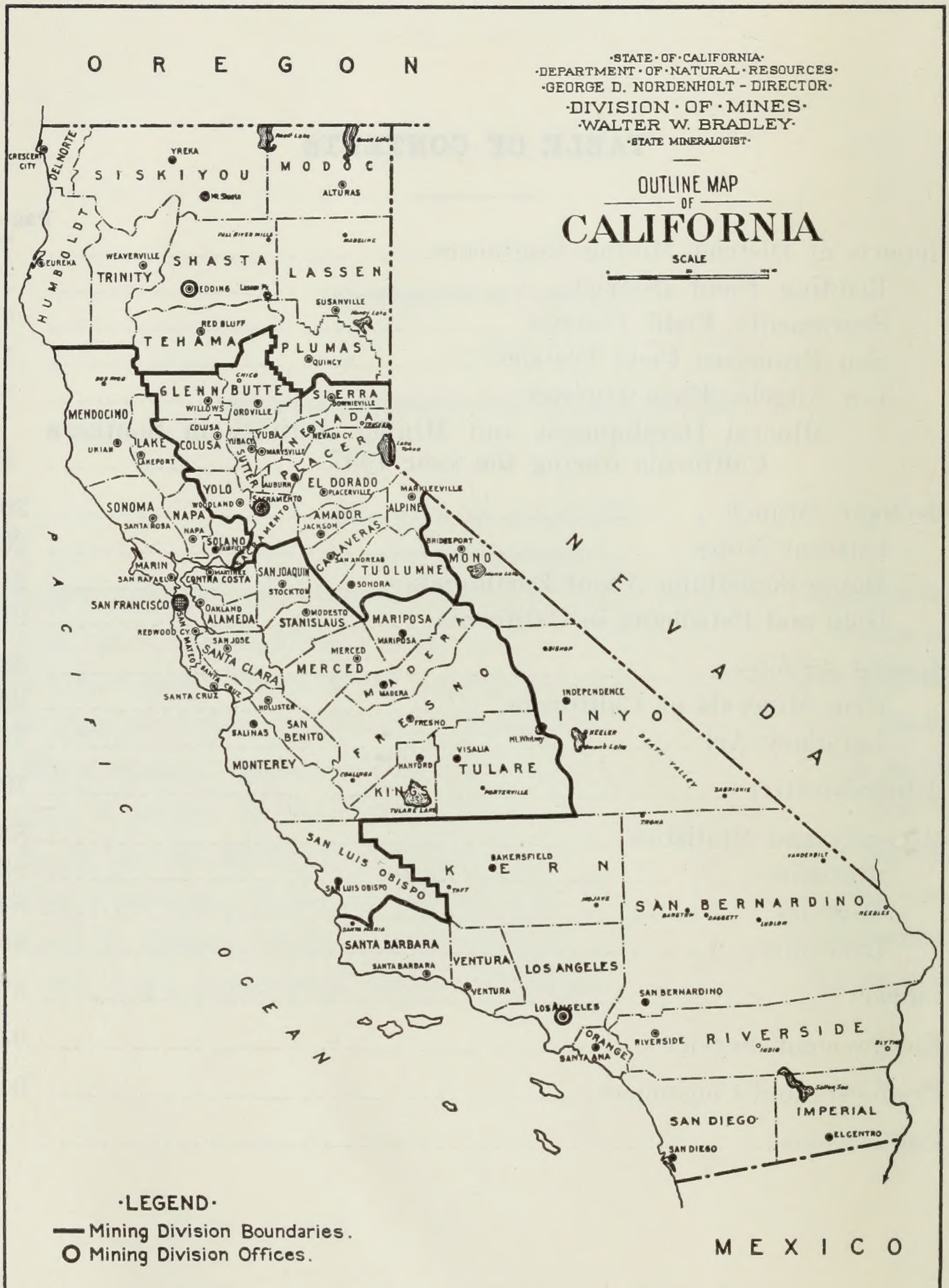

·STATE·OF·CALIFORNIA·
·DEPARTMENT·OF·NATURAL·RESOURCES·
·GEORGE D. NORDENHOLT - DIRECTOR·
·DIVISION·OF·MINES·
·WALTER W. BRADLEY·
·STATE MINERALOGIST·
OUTLINE MAP OF CALIFORNIA
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EL CENTRO
·LEGEND·
Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District, on account of unfinished field work. A special report on gold dredging is in preparation.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

MINERAL DEVELOPMENT AND MINING ACTIVITY IN SOUTHERN CALIFORNIA DURING THE YEAR 1937

By W. B. Tucker, District Mining Engineer

The total value of the mineral production of California for the year 1937, is estimated by the Division of Mines, under the direction of Walter W. Bradley, State Mineralogist, to have been $351,487,000.

There were 50 different mineral substances produced during 1937.

The following southern California counties were producers of a great variety of these minerals:

County	Number of mineral products
Imperial	11
Inyo	18
Kern	18
Los Angeles	20
Mono	7
Orange	13
Riverside	14
San Bernardino	25
San Diego	13
Santa Barbara	10
Ventura	8

The salient feature of the 1937 mineral production was the increase in production and value of the metals: Gold, silver, quicksilver, lead, tungsten and iron.

Structural Materials: Of the structural group practically all materials showed an increased production and value with the exception of cement. They were as follows: Clay products, granite, lime, marble (onyx and travertine).

Industrial Minerals: There was a small increase in production and value of the following minerals: Bentonite, diatomite, pumice, volcanic ash, silica, sillimanite (andalusite and kyanite), sulphur, and talc.

Salines: There was an increase in production and value of borates, potash, soda, and salt.

Metals.

California continued to hold its position as the leading gold producing state of the United States; the quantity in 1937 was greater than in any year, since 1883, with the highest annual gold value since 1861, the production being 1,164,000 fine ozs. with a value of $40,740,000.

All other major metals showed an increase in output with the exception of zinc.

The silver and copper yield, each had a total value over the million dollar mark.

Mining Activity. There has been increased activity in all the gold districts in southern California during 1937. There has also been a considerable revival in the mining of tungsten ores in Kern, San Bernardino and Inyo counties. There was also some revival of mining in the silver-lead districts of Inyo and San Bernardino counties. There is some activity in the mining of iron ores in Inyo and San Bernardino counties. In Inyo County high-grade magnetite ore was being mined from the Hoot Owl Iron deposit situated in the Argus Range of mountains, 20 miles north of Trona, the ore being shipped to San Francisco. In San Bernardino County high-grade hematite was being mined from Cave Canyon Iron deposits near Baxter, a station on the Union Pacific Railroad, and shipped to cement plants.

There was a revival of quicksilver mining in Inyo, Kern, San Luis Obispo, and Santa Barbara counties.

Gold.

Mine development and the production of gold showed a considerable increase in the following counties in southern California:

Imperial County.

The most active mining district in the county was the Cargo Muchacho district, situated in the Cargo Muchacho Range of mountains, 4 miles northeast of Ogilby, and 18 miles northwest of Yuma.

There were four producing properties under operation during the year. The *American Girl Mine* was operated by the *Socorro Mining Company,* Mrs. J. J. O'Brien, president, A. T. Balmforth, secretary, W. B. McMillen, superintendent, Ogilby, California. Increased the capacity of flotation plant to 150 tons per 24 hours.

Forty-five men employed.

Cargo Muchacho, Madre and Padre Mines, being operated by *Holmes and Nicholson Mining and Milling Company;* Kenneth Holmes, president and manager. At present extracting ore from the Padre and Madre mines. Ore hauled by truck 12 miles for treatment in company's 50-ton cyanide plant at Winterhaven.

Twenty men employed.

Sovereign Mine. This property is operated by the Sovereign Development Company. Courtney Baylor, president; Thomas L. Woodruff, vice president and manager; M. Dick, secretary, 30 Bay State Road, Boston, Mass. Mine office, Ogilby, California.

Ore hauled by truck from mine a distanct of 2 miles for treatment in company's 30-ton cyanide plant.

Fifteen men employed.

Tumco Tailings. Riggs and Horgan operated 20-ton cyanide plant on tailings from Golden Queen, Golden Crown and Golden Cross mines, continuously during the year, employing six men.

Inyo County.

Gold mining was quite active throughout the county, and a number of new and old properties resumed operations during the year.

Bishop Creek District: The *Cardinal Mine* was operated continuously during 1937, and was the largest gold producer in the county.

The operating company was the Cardinal Gold Mines Company; Victor Bongard, superintendent.

Operating 150-ton flotation plant.

One hundred men employed.

Polita Mine near Bishop was operated by H. W. Van Loon, of Bishop. Ore was treated in a 25-ton amalgamation and flotation plant.

Keeler Gold Mines Inc., Roy Troeger, manager, 972 Fourth Ave., Los Angeles. Operated the *Kruger Mine* in Cerro Gordo Mining district. near Keeler. Also treated ore in 50-ton cyanide plant from *Tucki, Del Norte Mines* situated in the Wildrose Mining district in Panamint Range of mountains.

Twelve men employed.

In Wildrose mining district the *Cashier* and *Skidoo* mines were operated by Roy Journigan, the ore being treated in 20-ton cyanide plant of the *Journigan Mining and Milling Company.* Roy Journigan, manager.

Fifteen men employed.

In Argus Range of mountains, there was increased activity in gold mining. The *Ruth Mine,* situated 14 miles north of Trona, was taken over by *Burton Bros. Inc.,* George Wyman, and Nels Sweetzer of Mojave. Installed a 40-ton cyanide plant, which is to be increased to capacity of 70 tons per day. Also acquired the *Davenport Mine* which is being developed.

Twenty-five men employed.

Mohawk Mine was acquired under lease by L. E. Netherton, of Randsburg. Ore mined being treated in 20-ton cyanide plant.

Twelve men employed.

This property is 14 miles north of Trona in Argus Range of mountains.

There were eight producing gold mines in Inyo County during 1937.

Kern County.

Gold mining continued active during 1937, there being fifteen producing properties under operation. The most active districts were Mojave, Tropico, Randsburg, Kernville, Keyesville. In the Mojave district the following mines were under operation:

Golden Queen Mine operated by the Golden Queen Mining Company, William Browning, manager. Offices, Pacific Mutual Bldg., Los Angeles, California.

This company increased its cyanide plant to treat 400 tons per day. The mine is the largest producer of silver in the state.

Lode Star Mine was developed during the year to be one of the largest producers in the district. Ore mined is shipped to the Golden

Queen Mill for treatment at the rate of 150 to 200 tons per day. Installed new Imperial type of Ingersoll-Rand compressor and continued development on the Echo tunnel level. John Rogers, of Willow Springs, is general manager of the property.

Fifty men employed.

Other mines under production are *Soledad Extension, Standard Whitmore, Eureka* and *Pride of Mojave.*

At Tropico:

The Tropico Mines were operated by Burton Bros. Inc.; Clifford Burton, president and manager.

This company increased the capacity of the mill to 100 tons per day. Besides treating mine run of ore, the mill was operated as a custom mill, treating ores of other mines in the district.

At Middle Butte:

The Cactus Queen Mine was acquired by the *Cactus Mines, Inc.;* Harvey Mudd, president; Roy Moore, general manager; offices, Pacific Mutual Bldg., Los Angeles, California.

This company purchased the *Blue Eagle group* of mines, and has developed the property into one of the large gold producers in this district. Ore from the mine is treated in 100-ton cyanide plant.

Seventy-five men employed.

Middle Buttes Mine, was acquired under lease by George Holmes, of Mojave, and ore mined is hauled by truck to Golden Queen mill for treatment.

Twenty men employed.

Randsburg District:

The following mines are under operation: Yellow Aster, Big Butte, Operator, Buckboard, King Solomon and Black Hawk.

At the *Yellow Aster Mine,* the *Anglo-American Mining Corp.,* Walter Brown, president; H. W. Klipstein, vice president; A. W. Frolli, manager; Mills Bldg., San Francisco, California, plans to mine 2000 tons of ore from glory hole with steam shovels to deliver it to crushing and screening plant, where oversize material is eliminated, converting 4 tons into 1 ton of $\frac{1}{4}$-mesh size, delivering 500 tons of ore to amalgamation and concentration plant, tailings to cyanide plant. The 1200-ton cyanide plant operated to capacity.

Forty-five men employed.

Kernville District:

The Big Blue and Lady Belle mines at Kernville were operated continuously during the year by *Kern Mines Inc.* Eirind Knutsen, manager, 605 Market St., San Francisco, California.

Ore from above mentioned mines treated in 100-ton flotation plant.

Thirty men employed.

Keyesville District:

Mammoth Mine was being developed by G. W. Russell, Isabella, California.

Six men employed on development.

Keyes Mine was taken over under bond and lease by *Barlu Enterprise Mining Company;* Harry Lucas, manager.

Ore mined from winze from tunnel level is milled in 10-stamp mill. Ore being milled is reported to carry from $25 to $50 per ton in gold.

Pennsylvania Mine. Acquired by F. J. Roberts, of Los Angeles. After driving a tunnel 1400 feet in length, cut ore shoot 100 ft. in length, average width 8 in. reported to carry $100 per ton in gold. Ore being milled in Mammoth mill.

Four men employed.

In Piute Mining district, the following mines were under operation during 1937:

Burning Moscow Mine, operated by the *Piute Mining Company,* William Quackenbush, vice president and manager. This company also took over the *Skyline Mine* situated in Pine Tree Canyon, 15 miles northwest of Mojave. Development consists of four shafts with 4000 feet of underground workings. Ore treated in 25-ton amalgamation and concentration plant. Twenty men are employed.

Gwynne Mine was operated during the summer months by Otto and Jack Gerenger, of Mojave. The property is situated in Green Mountain Mining district in Piute Mountains, 25 miles north of Caliente. Mine developed by tunnel 1750 ft. in length with a shaft 300 ft. in depth. Mill has a capacity of 25 tons per day; ball mill, amalgamation plates and concentrator.

Seven men employed.

Los Angeles County.

The principal productive gold mines in the county were the Governor, Rogers-Gentry and Western Graphite Company's custom mill.

Governor Mine is owned and operated by Chas. H. McWilliams and J. F. Gage, 725 So. Figueroa St., Los Angeles. Development consists of tunnel 800 feet in length from which a vertical shaft is sunk to a depth of 430 ft., with over 1500 ft. of underground workings. Ore is hauled by truck from mine to mill a distance of 5 miles. Mill consists of amalgamation and flotation plant and has a capacity of 40 tons per day.

Fifteen men employed.

Rogers-Gentry Mine is situated 6 miles south of Neenach. Owners W. T. Rogers and R. J. Gentry, Neenach. Developed by three shafts, with depths of 300 ft. and a tunnel 150 ft. in length, with winze 200 ft. deep. Ore milled at mill of Burton Bros. Inc., Tropico, and Western Graphite Company's mill.

Western Graphite Company's custom mill operated by C. W. Jones, 337 West Avenue 26, Los Angeles. Capacity of plant is 50 tons per day. Treatment is by flotation and concentration.

Twelve men employed.

Mono County.

Activity in gold mining in this county showed a considerable increase, the most active districts being Bodie, Mono Lake and Chidago.

At Bodie, the *Standard Cons. Mines Company's* property, owned by J. S. Cain, of Bodie, operated under lease by the *Roseclip Mines Co.,* Henry W. Klipstein, president, Mills Bldg., San Francisco; K. E. Peters, manager. Installed 250-ton cyanide plant to treat 500,000 tons of dump material reported to have an average value of $4 per ton in gold and silver.

Fifty men are employed.

In the Mono Lake district, the *Simpson Mine*, west of Mono Lake, was operated by the *Mutual Gold Mining Company,* Spokane, Washington; J. A. Vance, general manager.

Development consists of a tunnel 1200 ft. in length and a shaft 300 ft. deep with 5000 ft. of drifts and crosscuts. Ore mined is treated in 10-stamp mill, with amalgamation plates and concentrators.

Thirty men are employed.

May Lundy Mine is situated in the Lundy Mining district. Owned by Thomas Hanna, Martinez, California. Installed 40-ton flotation plant for treatment of 60,000 tons of tailings said to carry $4.23 per ton in gold. Also rehabilitated power plant above Lake Lundy. Water to Pelton wheel drives 250 KVA generator, developing 180 h.p. at mill. Power line to mill from hydroelectric power plant is two miles in length.

Ten men employed.

In Chidago District, the *Casa Diablo, Sierra Vista* and *Last Chance* mines were operated on a small scale.

In Masonic District, the *Chemung Mine* was reopened by Johanson, of Los Angeles. A 25-ton amalgamation and concentration plant was installed to treat dump and mine run of ore.

Ten men employed.

In Silverado District, the *Silverado Mine* was acquired by the *Sierra Consolidated Mines Co., Inc.;* John J. Raskob, president; T. S. Davey, manager. Offices: Wellington, Nevada. Mine Office: Sweetwater, Nevada. Installed a 100-ton flotation plant.

Forty men are employed. The ore treated contains its main values in silver.

In Mammoth Lakes District, the *Mammoth Cons. Mines* property was taken over under lease and bond by the *Crystal Craig Mining Co.;* C. E. Wood, president, 5068 W. 20th St., Los Angeles.

Ten men employed on development.

Riverside County.

The most active mining districts were the Dale, Pinacate, and Vidal. In the Dale District, the *Gold Crown Mining Company,* George Novell, president and manager; offices, Petroleum Securities Bldg., Los Angeles, California, was the largest gold producer in Riverside Co.

The major tonnage of ore milled was mined from *Nightingale* and *Supply* mines in Dale District, San Bernardino County. Supply and Nightingale mines were equipped with electric-driven hoists and compressors. Ore hauled by trucks from above-mentioned mines.

Thirty men employed.

In the Pinto Mining District, the *Golden Bee* and *Ducky Boy* mines operated by E. Auclair, of Twenty-nine Palms, was a small producer of high-grade ore.

In the Pinacate District, the *Ida-Leona Mine* was operated by H. L. Nelson, of Perris. Development consists of two shafts 300 ft. deep, with several thousand feet of drifts and cross-cuts. Shipped high-grade ore to Midvale Smelter of United States Smelting, Refining and Mining Co., Midvale, Utah.

Fifteen men employed.

In the Vidal District, the *Mountaineer Mine* was operated by Mountaineer Mining Company, of Los Angeles; B. M. Stansbury, president; A. J. Bryant, superintendent; H. E. Olund, consulting engineer, 1117 Citizens National Bank Bldg., Los Angeles.

Development consists of two tunnels each 200 ft. in length. Shaft 200 ft. deep and several thousand feet of underground workings. Mine equipment consists of 100-h.p. Fairbanks-Morse diesel engine which drives a 75 KVA General Electric generator, Imperial Type No. 10 Ingersoll-Rand compressor and electric-driven hoist. High-grade ore mined is shipped to Magma Smelting Company, low-grade ore treated in 25-ton flotation plant.

Fifteen men employed.

In Chuckawalla Mountain Mining District, the *Red Cloud Mine* is owned by Red Cloud Mining Company, J. D. Huston, of Los Angeles, president.

The mine is situated in the Chuckawalla Mountains, 50 miles east of Mecca. Development consists of 3 shafts, with depths of 300 and 400 ft. Ore being mined from Red Head shaft which has been sunk to a depth of 400 ft. Several thousand feet of underground workings. Property recently acquired by Frank Ahlburg, 610 Vermont Ave., Los Angeles, California.

Ten men employed on development work.

In the Eagle Mountains Mining District, the *Black Eagle Mine* (copper, gold, lead and silver) owned by Black Eagle Mining Co., Sam Mosher, president, Signal Oil Bldg., Los Angeles, California, is being operated by *Imperial Smelting & Refining Co.*, Sam Mosher, president; C. LaV. Larzelere, secretary; H. E. Covey, superintendent. Development consists of tunnel 600 ft. in length and shaft 300 ft. deep with 2000 ft. of drifts. Recently completed the installation of 300-h.p. Fairbanks-Morse diesel engine. Electric-driven hoist and completed the construction of 150-ton concentration plant. Water for operations is secured from Cottonwood Springs, 23 miles southwest of the mine.

Thirty men employed.

San Bernardino County.

The most active mining districts were the Dale, Stedman (Ludlow), Imperial Lode, Barstow, and Atolia.

Carlyle Mine, operated by Carlyle Mining Corp., William A. Dorman, president; A. E. Cates, secretary; G. Gemmell, superintendent, Los Angeles.

Mine development consists of two tunnels, one 1500 ft. in length, the other 1200 ft. in length; with 2000 ft. of raises, winzes and cross-cuts. Mine equipment consists of compressors, aerial tram 2600 ft. in length from tunnel to mill.

Mill: Flotation plant with capacity of 60 tons per day. Power plant consists of 250-h.p. Fairbanks-Morse diesel engine direct connected to 150 KVA generator.

Twenty-four men are employed.

Jupiter Mine is in the Dale District, situated 7 miles NE. of New Dale. Operated by Frank H. Berger and Matt Gilbert, 619 N. Palm Ave., Los Angeles; Hugh Leonard, superintendent.

Development consists of a tunnel 200 ft. in length, also sinking shaft on the southwest end of the property. Ore mined is shipped to the Gold Crown mill for treatment.

Ten men employed.

In the Goldstone District the *Reward Mine* was operated by the Reward Mining Co.; Julian Itter, manager, Barstow, Calif.

Development consists of a tunnel 600 ft. in length on the vein, with raises and cross-cuts. The company installed a 20-ton amalgamation mill about 6 miles west of the mine.

Six men employed on development work.

In the Stedman District, 4 miles south of Ludlow, the *Bagdad Chase Mine* was under lease to *d'Aix Syndicate,* of Daggett; F. D. d'Aix, president and manager. Installed hoist and compressor; also retimbered shaft. Reported to be shipping 50 tons per week to Magma Smelting Co.

Six men employed.

American Mine. Owner Marcus Pluth, of Daggett. Under lease and bond to *American Mines, Inc.,* F. H. Merrill, president and manager. The property is situated in Sheep Hole Mts., 10 miles south of Amboy. Development consists of 3 tunnels each 300 ft. in length and shaft 115 ft. deep. Shipped a certain tonnage to the Gold Crown mill for treatment. Company installing a 25-ton mill on the property.

Ten men employed.

Imperial Lode Mines situated in the Lava Bed Mining District, 9 miles southwest of Lavic, a station on the Santa Fe Railroad. Owner, *Cave Springs Mining Corp.,* of Los Angeles. Under lease to F. M. Covey, Indio, California.

Property developed by tunnels and shafts. Installed a compressor, cars, track and screening and sorting equipment. The ore mined is lead-silver, with high values in silver. Shipped 500 tons of ore to Salt Lake smelters.

Ten men employed.

Telegraph Group of Mines. The property is situated in Solo Mining District, 17 miles east of Baker. Owner, Telegraph Mines, Inc., J. T. Hutton, president; Andrew Bauer, secretary, Long Baech, California. Under lease and bond to the *Solo Engineering Co.;* C. F.

Robbins, president and manager, Long Beach, Calif. Development consists of three shafts 100 ft. deep. Main working shaft 125 ft. deep with 1000 ft. of drifts. Mine equipment consists of hoist, compressor, cars and air drills. Mill consists of 25-ton amalgamation and flotation plant.

Ten men employed.

Lead-Silver Mines:

The principal activity in lead-silver mining was confined to the Cerro Gordo, Darwin, and Slate Range districts in Inyo County. The outstanding development being the reopening of the *Defiance, Independence,* and *Thompson mines* owned by the *Wagner Assets Realization Corp.* of Chicago. The property is under lease to the *Darwin Lead Company,* Col. Noble B. Judah, president; H. R. Montgomery, secretary; H. E. Olund, manager. Offices, 453 S. Spring St., Los Angeles. Was an active shipper of lead-silver ores and concentrates to Salt Lake smelters. Also installed 100-ton concentration plant for treatment of low grade ores from Defiance and Thompson mines. Development consists of a shaft on Defiance Mine 500 ft. deep on an inclination of 35° and 5000 ft. of drifts and cross-cuts. On the Thompson Mine there is a tunnel 1000 ft. in length. Ores mined are galena and lead carbonate with silver values.

Twenty-five men are employed.

Darwin-Keystone Mines, situated in the Darwin District, were operated by the Darwin-Keystone Mining Company, A. A. Rupel, president, Piru, Ventura Co., Calif.; A. Yoder, superintendent. Developed by tunnels and drifts totaling several thousand feet. Mine equipment consists of compressors, air drills and trucks. Shipped 800 tons of ore to United States smelter at Salt Lake City, Utah, carrying $1.75 in gold, 28 oz. in silver and 15% lead.

Twenty men employed.

In Cerro Gordo Mining District, the *Royal Mine,* owner, R. C. Spear Estate, of Lone Pine, Calif., was operated by *Cerro Gordo Extension Mining Co.,* J. P. Hart, president and manager, Keeler, California. Development consists of shaft 200 ft. deep and tunnel 1000 ft. in length. Mine equipment consists of hoist, compressor, air drills and truck. A number of shipments of ore were made to U. S. Smelting Co., Midvale, Utah. Average run of ore shipped, gold .115 oz.; silver 15.40 oz.; lead 20.20%.

Six men employed.

Santa Rosa Mine is situated in Cerro Gordo Mining District, 26 miles northeast of Keeler. Owner, Santa Rosa Mines Development Company, J. R. LeCyr, president; G. W. Dow, Lone Pine, trustee. Under lease to R. E. MacDonald and C. Grand, of Keeler. Development consists of incline shaft 340 ft. deep, with 5000 ft. of underground workings; also a number of tunnels 100 to 600 ft. in length. Mine equipment consists of hoist, compressors, air drills and cars. Galena and lead carbonate ore is being shipped to U. S. Smelting Co. smelter at Midvale, Utah. Ore shipped runs from 15 to 20% lead with 12 to 15 oz. in silver. About 700 tons of ore shipped in 1937.

Six men employed.

Sterling Mine (silver). Situated in Revenue Canyon in Argus Mountains, 30 miles north of Trona. Owner, Sterling Mining Co.; James Stevenson, president, Trona, Calif. Development consists of two incline shafts, one 100 ft. deep, the other 285 ft. and 500 ft. of drifts. Thirty-ton flotation plant.

Twelve men employed.

Slate Range Mine (Copper Queen) (copper, gold, lead, silver). Situated in the Slate Range of mountains, 9 miles northeast of Trona, Calif. Owner, Slate Range Consolidated Mining Co.; T. A. Wells, president, Bakersfield. Under lease and bond to *Gold Bottom Mines, Inc.;* Emil Bender, President; F. W. Handle, secretary; T. J. Nicely, manager, Bakersfield, Calif. Mine office, Trona, Calif.

Developed by tunnels and shafts; lower tunnel is 1000 ft. in length, with 6000 ft. of underground workings. Shipping selected ore to U. S. Smelting Company's smelter at Midvale, Utah. Ore shipped is galena and lead carbonate carrying gold and silver values. Reported to carry 0.63 oz. gold; 15 oz. silver; and 15% lead. Company has a 25-ton flotation plant located on east side of Searles Lake, 2 miles west of mine, in which second grade ore is concentrated to produce a shipping product.

The production during 1937 was $15,000. Property equipped with hoist, compressors and air drills.

Fifteen men employed.

Ubehebe Mine (lead-silver). It is situated in the Ubehebe District, 50 miles by road northwest of Death Valley Junction. Owner, A. Farrington Estate, Bishop, Calif.

Under lease to Grant Snyder and C. A. Rankin, Los Angeles. Ore is hauled by truck to Death Valley Junction for shipment to Salt Lake City smelters.

Ten men employed.

Carbonate Mine. Situated in the Panamint Range of mountains, 40 miles northeast of Zabriskie, a station on Tonopah & Tidewater Railroad. Operated by John P. Madison and H. L. Hellwig, 400 Post St., San Francisco, Calif. Mine address, Shoshone, Calif.

Developed by three tunnels with about 5000 ft. of underground workings. The ore is hauled by truck to Zabriskie for shipment to smelters at Salt Lake City, Utah. The ore is lead carbonate and galena with silver values. Ore shipped reported to carry 15% lead and 10 to 15 oz. in silver. Equipment consists of trucks, compressor, air drills and cars.

Ten men employed.

Iron:

Hoot Owl Iron Deposit. Situated in Argus Range of mountains, 14 miles north of Trona. Owner, Lloyd Helm, of Inyokern, Calif. Operated by Ekstrom & Bradley, 320 Market St., San Francisco. Iron ore hauled by truck to Trona, California, and shipped to San Francisco.

Titaniferous iron deposits of the San Gabriel Range of mountains in Los Angeles County: *The DuPont Co.,* of New Jersey, has acquired

a number of deposits located in Mill Creek and the Mount Gleason area. The company is making an active survey of the deposits to determine extent and available tonnage, also conducting experiments for treatment of the ores for the purpose of manufacturing titanium oxide.

Quicksilver:

Inyo County.

The Coso Quicksilver Mine situated near Coso Hot Springs in the Coso Range of mountains, 14 miles NE. of Little Lake, Inyo County. Owner, F. J. Sanders, Santa Barbara, California. The property has been acquired by A. W. Leege, of Santa Barbara, Calif., who has installed a 20-ton Herreshoff furnace.

Ten men employed.

Kern County.

Cuddeback Quicksilver Mine situated 13 miles northeast of Woodford, a station on S. P. Railroad. Owner, Cuddeback Cinnebar Corp., C. G. Cuddeback, Tehachapi, Calif. Under lease and bond to *Wallabu Mining Co.,* Bakersfield, Calif. Dan Murphy, president; Percy Blodgett, superintendent. Operating 50-ton Gould rotary furnace.

Twelve men employed.

Tungsten:

San Bernardino County.

Atolia Mining Co., Clifford Dennis, manager, Atolia, Calif. Installed a new 100-ton concentration plant. Some 250 leasers were employed on the company's property in mining ore and delivering it to the mill for treatment.

Inyo County.

There was a renewal of activity in the mining of tungsten ores in the Bishop district. The following companies installed mills on their several tungsten deposits.

Tungsten Milling Company. Raymond Stolle installed 120-ton concentration to treat tailings from *Tungsten City Mines.* (Developed a combination vacuum and electrostatic separator). Table concentrates 30% WO_3, separator cleaned concentrates to 70% WO_3.

El Diablo Mining Company. H. O. Johanson, Bishop—has a lease on *Tungsten City Mine;* 60-ton concentration plant with Stolle electrostatic separator.

Pacific Tungsten Co., O. T. Wilkerson and Ralph Moore, of Bishop —*Rossi Mine,* 3 miles south of Bishop; 50-ton concentrator mill. Table concentrates 30%. Product cleaned by Stolle electrostatic separator—to 70% WO_3 concentrate.

U. S. Vanadium Company reopened *Pine Creek Tungsten Mine.* Rebuilt 100 ton mill—and road from property via Rock Creek to mine. Treating 100 tons per day.

Thirty men employed.

Mono County.

Black Rock Tungsten Mine situated south of Benton, Mono County, acquired by *Tungsten Corporation of America;* Fay Wright, president, Signal Oil Bldg., Los Angeles, California. Installed 150-ton concentration plant, put in operation November, 1937.

Non-metallic Minerals:

SULPHUR: *Sulphur Diggers,* Inc.; Sidney Wood, Jr., president, 3923 6th St., Los Angeles, California. Operated *Crater Sulphur Deposits* in Last Chance Range Mts., 68 miles east of Zurick, Inyo County. Installed 60-ton retort at Zurick. Shipped approximately 8000 tons of sulphur, grade 96% to 98%. Suspended operations September 1 due to market conditions, and cost of hauling from property to Zurick.

TALC: The following properties operated continuously during the year. *Sierra Talc Co.,* operated Darwin and Saline Valley Talc mines with grinding plant at Keeler. *Pacific Coast Talc Co.* operated *Mt. Whitney Talc Mine* near Darwin; also mines near Riggs, San Bernardino County. *Acme Talc Mines* near Tecopa were operated by the *Western Talc Company.*

BARITE: Reopening of *Poso Barytes Mines,* Inyo County, by *Western Barium Company,* of San Francisco. Also construction of Barium Products plant at Rosamond, California. Development of Barium deposits near Earp, San Bernardino County, by *California Talc Co.,* of Los Angeles

BENTONITE: Development of extensive deposits of bentonite by *California Talc Company,* near Hector, San Bernardino County.

WOLLASTONITE: The development of a large deposit of this calcium metasilicate ($CaSiO_3$) in Radamacher District, near Randsburg by *Johns-Manville Co.,* is progressing; and they are mining material for use in a new plant under construction in Los Angeles for manufacture of mineral wool.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In this issue

Three outstanding things in the State of California are ever before the geologist's attention: Earthquakes, Gold, and Petroleum. In this issue of the Journal some of the broader points of view are taken of these subjects and told in a simple manner by two eminent scientists:

(1) "Doing Something About Earthquakes," by Commander R. R. Lukens, United States Coast and Geodetic Survey.

(2) "Gold and Petroleum in California," by Waldemar Lindgren, the veteran Economic Geologist of America, well known especially in this state by his work in the Sierra Nevada.

From time to time the Geologic Branch expects to publish an occasional popular paper of this sort from the pen of some famous geologist or engineer. In an earlier issue (January-April, 1933) for example, "Lakes of California" was presented by America's outstanding physiographer and geologist, the late Dr. William Morris Davis.

In press

In a few months' time, the new colored geologic map of the state will be ready for distribution. So also will "Minerals of California" (Bulletin 113) and "Bibliography of the Geology and Mineral Resources of California for the years 1931 to 1936, inclusive" (Bulletin 115).

In preparation

A new book, "Geologic Formations and Economic Development of the California Oil and Gas Fields" is now in preparation by a large number of contributing geologists who are actively engaged in the petroleum industry. The preparation and editing of this book is under the direction of the Geologic Branch of the Division of Mines.

DOING SOMETHING ABOUT EARTHQUAKES

By R. R. LUKENS, Commander, U. S. Coast and Geodetic Survey

Nearly everyone is familiar with Mark Twain's classic remark about the weather. He might have gone a little further and mentioned earthquakes as well as weather. However, since Mark Twain's time meteorologists have made great strides in their studies of weather predictions and seismologists and engineers are rapidly coming to grips with the earthquake problem.

Of course, even the most brilliant scientist never hopes to find a way of preventing earthquakes. He is also very reticent regarding the possibility of even predicting earthquakes, but he does know that

FIG. 1. What happened to a building not designed to resist earthquakes. Helena, Montana, 1935.

ever since the appearance of man on this planet, earthquakes have occurred. They are occurring today and there is no evidence of any diminution in the number or severity of such shocks. In fact, more than 20,000 earthquakes occur yearly; a widely recorded shock every fourteen hours; and a destructive earthquake every six and one-half days.

If earthquakes can not be prevented, the question naturally arises as to what can be done to lessen their destructive effects on human life and the works of man. Probably the most severe earthquake ever to occur in this country was the New Madrid, Missouri, shock in 1811. Great topographic changes resulted from this earthquake, but, as the country was only sparsely populated and the few buildings were mostly log cabins, there was but little property damage. On the other hand,

consider the Long Beach earthquake in 1933. As an earthquake, it did not rate very high. Although of considerable intensity at the epicenter, the area covered was relatively small. Unfortunately, this area included a section of dense population—and, from an earthquake standpoint, much inferior building construction. The result was a terrific property loss and a considerable loss of life. Had the Long Beach

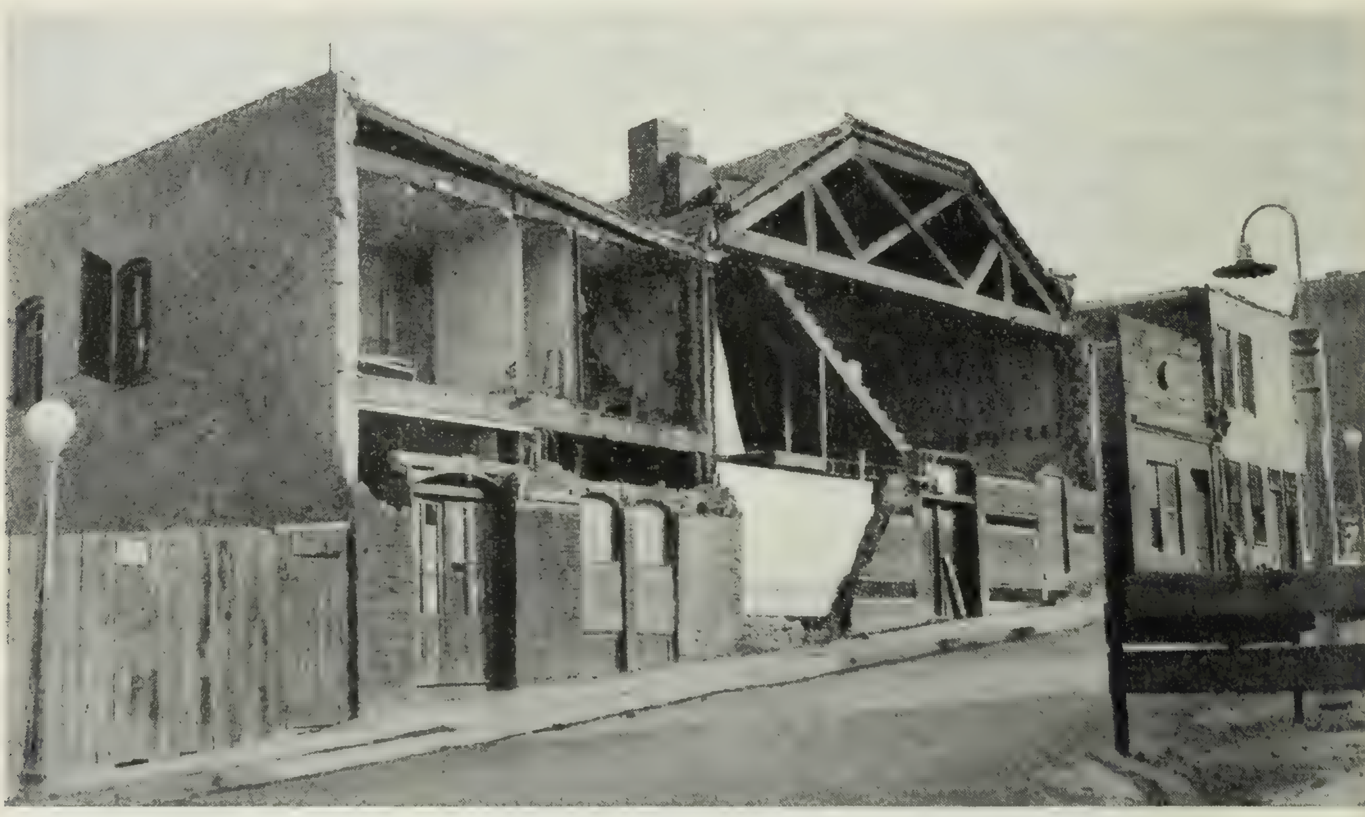

FIG. 2. The front of this building was shaken down by the Helena, Montana, earthquake of 1935.

earthquake occurred out in the arid, unpopulated portions of Nevada or New Mexico, it would hardly have been worth a single paragraph in the newspapers.

In 1929 a strong earthquake occurred on the Grand Banks, in the Atlantic about 1000 miles east of Boston. This disturbance was under the waters of the Atlantic Ocean and ordinarily would not have caused much damage, except for the fact that most of the Atlantic cables converge at this point. Every one of those cables was snapped with consequent interruption in transatlantic communication.

For many years seismologists studied earthquakes from the purely scientific approach. They developed sensitive seismographs which recorded earthquakes thousands of miles away. They also studied the rates and paths of travel of the various types of waves through the core of the earth and through the surface areas. The net result of these studies was the ability to locate the epicenter of an earthquake with considerable accuracy and to obtain information as to the materials making up the core of the earth.

This was all right in its way, but it gave the structural engineer no information whatever as to what forces he must build against when designing a structure in an area of known seismic activity. For example, the sensitive seismographs around the San Francisco Bay area in 1906 were either knocked off their supports or the records went off the scale, so that they gave no information as to the actual earth movements during that earthquake.

For many years there has been a tendency to try to solve the earthquake problem by ignoring it. Easteners have poked much fun at San Franciscans for always referring to the 1906 disaster as "the fire." In recent years, however, there has been a great change in sentiment. Today the attitude is, "Yes, we have earthquakes. We have had them for hundreds of years and will probably have them for hundreds of years in the future. How can we design buildings and structures which will stand through the worst earthquake that may reasonably be expected?" That is the proper approach to earthquake problems.

The bureau of the federal government charged with earthquake investigations is the U. S. Coast and Geodetic Survey. In 1930 that bureau, assisted by the Bureau of Standards and other institutions and individuals interested in seismology, developed the so-called strong-motion seismograph. This instrument works automatically and is so designed that when a fairly strong earthquake occurs, the mechanism starts and continues recording for one minute and then stops. A subsequent shock will start it off again. The various earth motions are registered by beams of light shining on photographic paper on a revolving drum. The strong motion seismographs are small but neces-

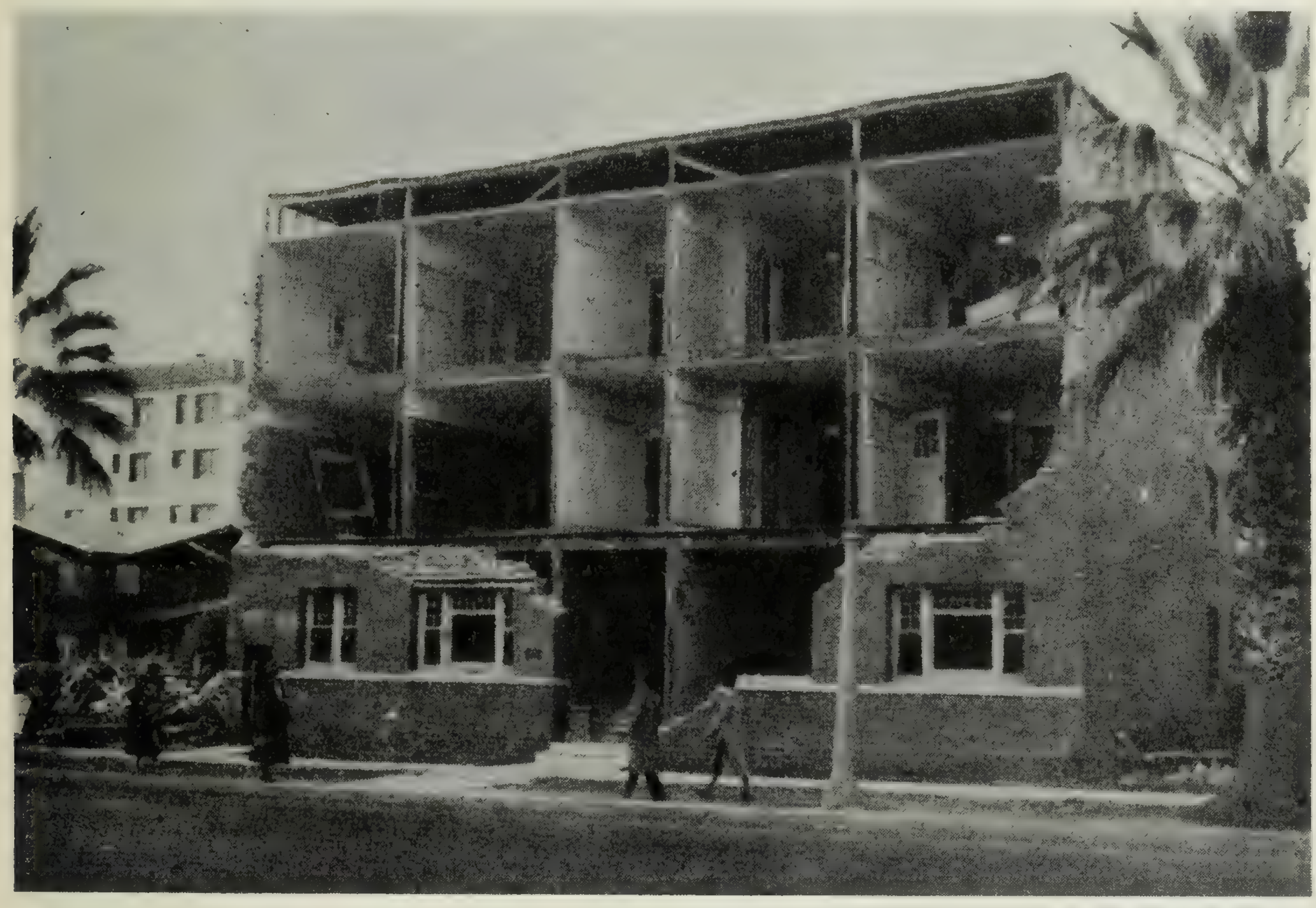

Photo by Walter W. Bradley

FIG. 3. Brick-veneer front shaken off in Long Beach, Cal., earthquake of March 10, 1933. This apartment house was just across the avenue from the tall Class A hotel shown in Fig. 4.

sarily of rugged construction. When the news came of the severe earthquake at Helena, Montana, on October 18, 1935, two observers at San Francisco loaded a strong motion seismograph in a light truck and started for Helena, hoping to get the instrument set up in time to record any possible aftershocks. In going over the mountains the truck went into a skid and turned over. Neither observer was seriously

hurt and upon righting the truck, they found they could proceed on their way. Arriving at Helena, the instrument was set up and successfully recorded the subsequent shock of October 30. It had gone through the truck accident without injury.

The first record from a strong-motion seismograph in the United States was obtained at Long Beach on March 10, 1933. This was an

Photo by Walter W. Bradley

FIG. 4. Villa Riviera, a Class A structure at Long Beach, Cal., not damaged by the earthquake of March 10, 1933. See also Fig. 3.

historic event in seismology because for the first time in the United States, earth movements near the epicenter of a strong earthquake were actually measured. The Long Beach and Helena earthquakes are the strongest shocks recorded by strong-motion seismographs to date.

There are now twenty-six strong-motion seismographs located at strategic points in northern California and twenty-four in southern California.

With the study of the strong-motion records, more and more light is being thrown on the nature and extent of seismic forces, against which the structural engineers must build. Today the studies are only

in their initial stage. The final test will come when a major earthquake occurs. We have every reason to believe that at least a portion of the strong-motion seismographs will function and produce invaluable records of that earthquake which we all *hope* will never come.

The instrumental work is only one phase of the cooperative earthquake investigation now being carried on in the Pacific coast area. Throughout that section there are thousands of volunteer observers. These consist of postmasters, public utility employees, lighthouse keepers, and citizens in general. Each is supplied with a questionnaire in the form of a postcard. When an earthquake is felt, the observer fills out a card, the questions being carefully framed to give a complete picture of the strength and characteristic of the shock, and mails it to the U. S. Coast and Geodetic Survey, 75 Appraisers Building, San Francisco. A trained seismologist studies these cards and assigns the relative intensity on a scale of 1 to 10, according to the description on each card. The various intensities are plotted on a map and lines of equal intensity drawn. These lines, known as isoseismals are usually more or less circular in shape and at the center of the circles is the epicenter, or origin of the shock. A glance at one of these maps gives a clear picture as to the intensities of various areas and the total area over which the shock is felt.

Of course, many of the cards bear apparently conflicting information. It is well known that an earthquake is felt much more strongly on filled-in ground than on solid rock. In the 1906 earthquake there was a great difference in apparent intensity between lower Market

FIG. 5. A strong motion seismograph being installed.

Street and nearby Telegraph Hill. The former is on filled ground over deep mud and the latter is solid rock. All reports, therefore, require careful evaluation by the seismologist.

At the end of each quarter, a mimeographed publication is issued, giving all the information collected concerning each earthquake recorded during that period. This information is not only valuable

to seismologists but is equally sought by insurance underwriters to assist them in formulating earthquake insurance rates in different localities.

In this brief article it is impossible to give the complete setup in the current seismological program. Suffice it to say, it is a highly cooperative one in which valuable work is being done by the University of California, Stanford University, California Institute of Technology, the Seismological Research Laboratory at Pasadena, the Seismological Society of America, and many individual public-spirited citizens. While the Pacific coast and California, in particular, is a region of considerable seismic activity, a study of earthquake history quickly reveals the fact that no point in the United States can be said to be immune from earth shocks. It is, in reality, a national problem and should be approached from that viewpoint. In the meantime, however, the Pacific coast area affords a natural laboratory for seismic research and it is only natural that the work should start in that locality.

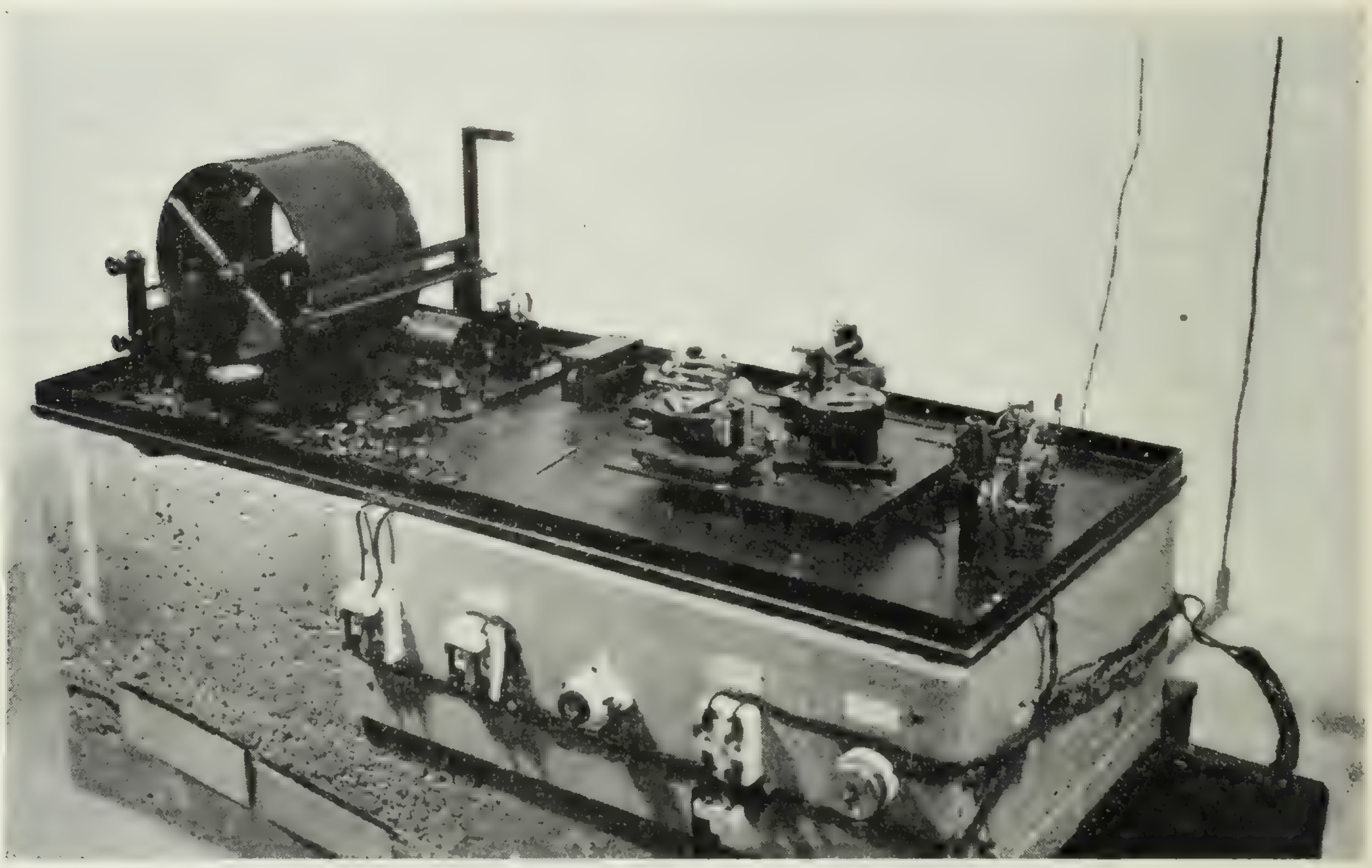

FIG. 6. A strong motion seismograph set up for operation. These instruments record the actual earth movements during a strong earthquake.

GOLD AND PETROLEUM IN CALIFORNIA

By Waldemar Lindgren *

The following pages contain little that is new, but simply call attention to the geological factors that have influenced the resources and the production of the two most important mineral products of California.

The gold deposits of California were first discovered in 1848 at Coloma, El Dorado County, and the enormous production rapidly spread the fame of the State all over the world as the gold land *par excellence.* Throughout the years this proud position among the states has been maintained, except when temporarily eclipsed by those flashing meteors of epithermal deposits like Cripple Creek and Goldfield. Of late the Canadian gold production from the province of Ontario has exceeded that of California.[1]

Thirty years later, about 1876, the petroleum of California began to appear in the list of mineral products and its amount increased rapidly. At the present time its value entirely overshadows that of the gold. The lowest value of the gold production was in 1929 when it fell to about eight and one-half million dollars. But the present value of the annual petroleum production is rather on the order of two hundred million dollars. While the gold production mainly comes from the central Cierra region, the petroleum production is chiefly in southern California. The enormous value of the rock oil is scarcely yet generally realized.

Several things are likely to attract the attention of the observant reader as he looks over the data on the mineral resources of the state published by the State Division of Mines and by the U. S. Geological Survey and (since 1931) by the U. S. Bureau of Mines.

In the first place the variety of mineral products is greater in California than in any other state. Fifty-nine products are listed in 1936 and there are several more included under the ''Miscellaneous'' heading. In the case of many mineral products, such as clay and cement, the amounts are higher than in other states excepting very few, such as Pennsylvania. The same applies to such products as gravel, sand and stone.

In the production of quicksilver and borates California has always occupied the first place. On the other hand many mineral products are lacking or meager in quantity in California. Such are iron ores, coal, feldspar, bauxite, fluorite, sulphur, phosphates and gypsum. Ores

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* Professor Emeritus, Department of Geology, Massachusetts Institute of Technology, Boston, Mass.

[1] Colorado, 1902—$28,468,700.
Colorado, 1910—$20,526,500.
Nevada, 1910—$18,873,700.
California, 1910—$19,715,440.
U. S. A., 1936—3,769,000 ounces.
Canada, 1936—3,720,000 ounces.
Ontario, 1936—2,370,000 ounces.
California, 1936, 1,077,000 ounces.

carrying lead, zinc and silver, all prominent products of many states are not plentiful. This lack is intimately related to the geologic structure of the great block facing the Pacific and, more particularly (1) to the absence of large pre-Cambrian areas normally containing pegmatites and iron formations, (2) to the absence of Paleozoic and Mesozoic lowlands carrying abundant vegetation producing coal and siderite, (3) to the absence of deep tropical weathering producing bauxite, (4) to the lack of large Paleozoic and Mesozoic limestone areas carrying the elements for phosphates, sulphur, etc. For the same reason the lead, zinc and silver deposits are scarce except in the eastern and northern sections where intrusives generated these ores, as well as some iron deposits of contact metamorphic origin. The Paleozoic formations largely consist of shale and sandstone with no oölitic iron ores. Silver is, of course, a by-product of the gold deposits but some of the few epithermal, late Tertiary deposits on the east side carried considerable amounts of rich silver ores; these, however, are largely exhausted, being confined to a zone near the surface.

There were many periods of metallization in California. The earliest, the pre-Cambrian, has left few traces. The latest took place in the latter part of the Tertiary and even reached over into the Pleistocene. It is characterized by the quicksilver deposits connected with late basic igneous rocks in the Coast Range. There were also in that time scattered gold-silver veins, a few in the Coast Range but most of them in the eastern part of the state. Most of these were of economic importance only temporarily, like Bodie in Mono County and others in the southern region, and they have contributed but little to the great totals of gold and silver production. They appear to be connected with large intrusions of intermediate magmas of Tertiary age of which there are few in the Sierran region and in the Coast Range.

But the time of principal metallization took place between the end of the Jurassic and the beginning of the Cretaceous. That was the time of the great batholithic intrusions of granodiorite and allied rocks. A veritable revolution, it resulted in the development of the great Pacific Coast intrusive mass extending from Mexico to Alaska and represented in a wider sense by intrusions along the South American coast from Colombia to Patagonia. These intrusions appear to have begun on the east side of the Sierra Nevada and even in the Coast Range. The first products were basic granular rocks but toward the east the intrusions changed to quartz diorite and granodiorite. A little later minor intrusives of quartz monzonitic character began to spread eastward into the Cordilleran margin, as far east as Colorado, the intrusions probably continuing into early Tertiary time.

The important thing was that the batholithic intrusions were followed in the fractured mass by the rising of hot solutions carrying silica and various metals, such as gold, silver, copper, lead and zinc, and these solutions deposited metal veins, some of great value, particularly along the batholithic margins and in the smaller intrusions.

There were similar deposits formed northward as far as Alaska but the richest part seemed to be concentrated in the batholith of Central California. Thus were formed, for instance, the gold-quartz veins of Grass Valley, and the great Mother Lode veins. The deposits contain

as a rule only small amounts of sulphides and little silver. The principal value is metallic gold.

As far as can be judged by remnants of the batholithic cover, the surface was then 3000 to 4000 feet above the present surface and there is reason to believe that the upper parts of the gold-quartz veins were considerably richer than the lodes now worked in the mines.

The intrusion of the batholith was followed by a long period of erosion and degradation. The rich upper parts were destroyed and much of the gold was carried away. But in the central part of California special conditions developed; to these we owe the preservation of a large part of the gold. As erosion slowed down a more gentle surface was developed and this continued during early Tertiary time.

Rivers were established on this gentle slope and formed veritable sluiceboxes in which much of the coarse gold was caught. In the course of time these superficial deposits would have succumbed to the continued erosion. But just then, probably at the end of the Miocene, volcanic eruptions of rhyolite, andesite and basalt broke out covering the gold-bearing channels and forming a thick mantle of tuffs and igneous rocks over the treasures of the early Tertiary rivers. Almost contemporaneously with this, at the end of the Pliocene, occurred the great uplift of the Sierra as if along a hinge on its western front and the erosion quickened suddenly. The present imposing canyons were cut through the volcanic capping down into the buried channels and into the underlying rocks. A great part of the gold in the old channels, added to by newly exposed quartz veins, was concentrated in these sharply incised canyons. Some gold was carried out into the plains but an enormous mass of it was caught in these new and narrow sluice boxes. And then the miners of 1848 arrived upon the scene. Their first crop was scooped up in the present canyons. The second crop (not yet entirely harvested) came from the Tertiary channels and was mined by underground methods where the channels had been exposed on the canyon walls, or by hydraulic methods where exposed on the surface. The third crop began to be gathered after a few years as the more promising outcrops of the veins of the batholith were sampled. Thus started the deep lode mining which now in many places has attained a depth of 4000 to 5000 feet. No doubt the ores will decrease in quantity and value but they will not be exhausted in many decades.

So this is the source of the California gold production: veins with relatively coarse gold; two later concentrations by the action of water erosion. Much was lost by disintegration and dissipation but enough was left to yield the imposing gold production of the State.

There are few regions in which the preservation and concentration has been aided by processes similar to those in California. The most striking example that comes to mind is Victoria, Australia. There, too, were the rich veins; there, too, were the Tertiary volcanic flows which sealed and preserved the superficial river deposits. On the other hand, there is the Canadian shield in Ontario and adjacent provinces, where the gold metallization, older than that of California, has been subjected to erosion since pre-Cambrian times and so should yield an enormous wealth. But there erosion was not stopped by overlying lava flows. Erosion proceeded unchecked and what was left of the Ontario placer deposits was ruthlessly destroyed by the Pleistocene ice invasion.

The total value of the gold produced in California 1848-1936 is given as $1,967,929,252 which, however, includes a few million dollars from Tertiary veins and small amounts from copper and lead ores; the figures for 1934 to 1936 are calculated on the basis of $35 per ounce whereas the rest of the production data are on the basis of $20.67+.[2] During the first decade (1851-1860) gold was produced to the value of nearly half a billion dollars; during the second decade the output was less than half as much. It gradually diminished to $147,080,006 in the decade 1881-1890; and gradually increased in the decade 1911-1920 to $191,989,332. The percentage of placer gold has gradually diminished from 100 per cent 1848-50 to 20 or 25 per cent about 1900. The notable increase in the production of placer gold reported since 1900 is caused by the great development of the dredging industry working on gravel channels at the western base of the Sierra Nevada. In 1935 the output of placer gold in California was 346,000 ounces against a total gold production of 890,430 ounces, of which only a small part came from copper and lead ores. The output of California has at times been exceeded by that of Colorado, Nevada, and Alaska, and the output of South Dakota has at times approached it. But nevertheless California still maintains its proud position as the premier gold producing state, and is likely to retain it for many years to come.

In its appearance, in its origin and in its deposits, gold is one of the most conspicuous mineral products. Since the remotest historical times it has been sought for, treasured and accumulated by men for ornaments and as a medium of exchange. No greater contrast can be imagined than that between the bright yellow metal and the black, thick, viscous rock oil—petroleum—seeping from the sediments or bursting out from its accumulated reservoirs when released by the drill. The oil does not even have a definite chemical composition. It is a mixture of various hydrocarbons ranging from gaseous methane (CH_4) to liquid and solid compounds, with minor amounts of sulphur, oxygen and nitrogen. The crude oils are divided into the lighter, or paraffin series, and the heavier, or asphalt series. The California oils belong chiefly in the latter division. A great number of products are formed by partial natural evaporation and by distillation. Among these products are gasoline, naphtha, kerosene, lubricating oils, vaseline, wax, asphalt and petroleum coke. In its crude state petroleum is used very extensively for fuel. There are many other uses such as road dressing, building paper and roofing. Next to the use of petroleum as a direct fuel comes its importance for the distillation of gasoline, universally used for gas engines.

The occurrence of petroleum in seeps from the outcrops of the Tertiary strata has been known for many years, but production on an economic scale by tapping of the underground reservoirs is comparatively recent. I note that in 1876 the production was only 12,000 barrels. The first refinery was started in Ventura County. In 1895 this had increased to 1,208,482 barrels, in 1919 it was 101,183,000 and in 1936 to 214,773,000 barrels. The three greatest producing states are Texas, Oklahoma and California. Oklahoma's annual production is somewhat larger than that of California, but both are spectacularly exceeded by

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[2] Hill, J. M., Historical summary of gold, silver, copper, lead and zinc produced in California, 1848 to 1926: U. S. Bureau of Mines, Economic Paper 3, pp. 22, 1929. Mineral Yearbook, U. S. Bureau of Mines, 1931-1936.

Texas whose output in 1936 was more than double that of California. The total production of California up to and including 1936 is given as 4,638,682,983 barrels. The value is a little difficult to ascertain correctly because of the fluctuating value of petroleum.

In 1936 according to the American Petroleum Institute the production as indicated above was 214,773,000 barrels divided in barrels as following:

San Joaquin Valley—97,627,000.

Coastal district including the Ventura and Santa Maria districts—22,901,000.

Los Angeles Basin including Long Beach, Santa Fe and other districts—94,245,000.

In the minor districts extending up to the vicinity of San Francisco in the Coast Range the output was insignificant.[3]

The total value may be set at something over $225,000,000. Adding to this the natural gas sold and the natural gasoline produced we obtain as a total about $277,000,000, an enormous amount compared to about $20,000,000 as the value of the gold production of 1936 (gold at $20.67+ per oz.).

The origin of the gold is spectacular: Hot solutions containing metals rise from the abyssal batholithic depths and deposit the metal in shining particles in brilliantly white quartz.

The origin of petroleum is inconspicuous in the highest degree: Vegetable and animal organisms, in part microscopical, accumulate on the surface at or near the shores of the oceans. Among these are diatoms, algae, jellyfish, small arthropods, etc., which sink to the bottom of the sedimentary basin after the death of the organism. This material, not yet petroleum, undergoes complex chemical changes even now imperfectly known, and in suitably porous beds petroleum develops by chemical and bacterial processes. It may migrate in these source beds and being light it has a tendency to rise above the water but below the gases; folding produces domes and anticlines in whose higher point the petroleum tends to collect; if released from gas and water pressure by the prospector's drill it may suddenly burst forth in large volumes. But the supply is limited and in time the yield of oil will decline. In California the petroleum is found almost entirely in the later Teritary beds ranging from Miocene to the Pliocene. As pointed out before, the great uplift which took place before or during the late Mesozoic intrusions was followed by a long period of erosion and degradation which extended far into the Tertiary.

The Coast Range existed only in part. The detritus from the Tertiary period of erosion accumulated along the foot of the Sierra Nevada in large quantities, reaching a maximum thickness of many thousands of feet in the southern end of the San Joaquin Valley and in the southern coastal region. Along the shores plankton developed and sank to the bottom making the source beds of petroleum. Covered again and again by later sediments, horizons rich in organic matter were, in this manner, repeatedly formed and entombed. Subsequent elevation folded and faulted these sediments resulting in the present

[3] A concise description of the oilfields of California may be found in W. H. Emmons, "Geology of Petroleum," New York, 1931, pp. 520-565.

complex structure of the Coast Ranges. Where these structures are not too badly crushed and eroded we now have great oil deposits accumulated in the domes and anticlines and other favorable traps. Thus we find in the southern oil fields numerous horizons where petroleum has been formed. Within 10,000 feet of sediment, there are in the region of Los Angeles as many as 10 to 15 oil zones.

The inorganic theory of the origin of oil is now generally abandoned. Likewise few geologists now believe that high temperatures prevailed during the development of oil. Probably 200°C. was rarely exceeded. Extensive migration of the oil across the beds probably rarely occurred. In the source beds, however, the oil could move until a suitable reservoir of fractured or porous bed was found and at the same time an impervious rock may have formed a barrier. The movement is most commonly upward on the dip as oil is lighter than water. Therefore a well drilled at the top of an anticline may yield only gas, while one drilled further down may develop oil or water or both. According to Trask [4] the amount of organic matter, not yet petroleum, in the source beds varies from one to seven or more per cent of the weight of the rock, the larger amounts occurring near the shore line. Of this (vegetable and animal) organic matter only about five per cent seems to be changed to oil by slow complex chemical and bacterial processes. It will be recognized that the formation of an oil pool is dependent upon many and complex conditions, and the prediction that oil may be found is always hazardous.

The great Mesozoic uplift of the western margin of the North American continent was initiated or followed by enormous batholithic intrusions. As a result of these the gold deposits were formed. The uplift was followed by a long continued Mesozoic and Cenozoic erosion and as a result tremendous masses of detritus accumulated in front of the rising coast. No doubt there were during this process innumerable pauses and oscillation. Plankton formed in abundance at the surface of the sea and sank to be covered by new sediments. From this animal and vegetable matter petroleum was gradually developed in numerous horizons. This oil migrated more or less freely in the source beds separating by gravity in suitable places which determined the locations of the future oil pools destined to become sources of wealth for coming generations.

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[4] Trask, Parker D., Origin and environment of source sediments of petroleum. Amer. Petr. Institute, 1932, p. 323.

One way of finding oil more cheaply. Oil and Gas Journal, Nov. 1937, pp. 120-129.

Nenitzescu, C. D., The present state of our knowledge on the origin of petroleum. J. Instit. Petrol. Technologists, 22, no. 166, 469-482.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

3—54783

GEM MINERALS OF CALIFORNIA

Their History, Occurrence, Description, and Means of Identification; Also a Simple and Satisfactory Polishing Technique.

By Francis J. Sperisen[a]

INTRODUCTION

In number and diversity of mineral species as well as in economic value California is unique. Over 420 species have been recorded of which over 50 were either first described from California or are not found elsewhere. The widespread explorations and development which followed the gold rush of '49 and the '50's, revealed valuable economic resources in many other mineral substances. Of the other metals, quicksilver and copper were early sought after and worked. Of the fuels, coal mining was quite active in the '60's; petroleum coming in some years later. Building materials, salines, and various industrial mineral raw materials have added greatly to the total and importance of the list.

Among the last-named group are various minerals and 'stones' suitable for gem-cutting and jewelry purposes. The first list of California's minerals was published by W. P. Blake in 1866, showing 75 different varieties. The second list appeared in 1884 as part of the Fourth Annual Report of the State Mineralogist, Henry G. Hanks, indicating a 100% increase in the number of known minerals and gave detailed descriptions for some of the localities. The third list, Bulletin No. 67 of the State Mining Bureau, in 1914, was followed in 1922 by Bulletin No. 91, each adding to the total number of recorded species and to our store of knowledge concerning California's resources in minerals. While the foregoing reports listed all known mineral species occurring in the state, one bulletin in particular was devoted to description of the gem stones and their occurrences: Bulletin No. 37, "Gems, Jeweler's Materials and Ornamental Stones of California," by Dr. George F. Kunz, 1905.

The above-noted books have for some time been out of print and due to awakening interest in the collecting and study of minerals and gems in the past few years, the demand has been so great that a new issue is desirable. The matter contained herein is a compilation of all authoritative data contained in the previous bulletins and on file in the library of the State Division of Mines.

The various species of gem minerals have been grouped under a chemical classification, a departure from the custom followed in the usual works on gems, so as to be more instructive and to show to better advantage the relationship of the various species.

For more detailed descriptions of the physical, chemical and optical properties of these gem minerals, the reader is referred to the new edition of 'Minerals of California,' Bulletin 113, by Dr. Adolf Pabst, Associate Professor of Mineralogy, University of California.

Owing to the widespread interest in the cutting and polishing of gem minerals a short chapter on Lapidary Art is included giving

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[a] Lapidary, San Francisco, Cal.

detailed information regarding the cutting and polishing of these stones. The technique is written as simply as possible and satisfactory results should be readily attained.

The author is indebted in particular to Walter W. Bradley, State Mineralogist of California, for help and assistance rendered, as well as to Henry Symons, Curator and Statistician of the State Division of Mines.

New minerals and localities are constantly being discovered in California and it is hoped this list may be the means of adding to the fund of knowledge already available, to increase interest in the minerals and mineral development of the State and to be of value to those who are seriously interested in the collection and study of the gem minerals.

The scope of this work includes all those minerals which have been used for jewelry purposes or for personal adornment.

THE GEM MINES OF CALIFORNIA

From the time of their discovery in the late 70's and early 80's the gem mines of the southern part of the state produced a notable quantity of valuable minerals, in a wide variety of types and colors. The production continued for several decades and extended into the present century.

The peak production since 1900 was recorded in 1906 with a total output for the State of $497,090. Since then the annual value of the gems produced has dwindled, the latest figures available (1936) being $2,878.

The all-time low since operations started was reached in 1918 when only $650 worth of gems was produced.

As will be noted from the table[1] herewith, the production of gem materials in California has been somewhat irregular and uncertain since 1911. The compilation of complete statistics is difficult owing to the widely scattered places at which stones are gathered and marketed, for the most part in a small way.

Total Production of Gem Materials in California.

The value of the gem output in California annually since the beginning of commercial production is as follows:

Year	*Value*	*Year*	*Value*
1900	$20,500	1919	$5,425
1901	40,000	1920	36,056
1902	162,100	1921	10,954
1903	110,500	1922	1,312
1904	136,000	1923	13,220
1905	148,500	1924	4,800
1906	497,090	1925	10,663
1907	232,642	1926	9,049
1908	208,950	1927	7,035
1909	193,700	1928	22,200
1910	237,475	1929	26,850
1911	51,824	1930	3,540
1912	23,050	1931	5,607
1913	13,740	1932	4,961
1914	3,970	1933	690
1915	3,565	1934	2,456
1916	4,752	1935	945
1917	3,049	1936	2,878
1918	650		
		Total	$2,260,698

[1] Symons, H. H., California Mineral Production for 1936, Bulletin 114, State Division of Mines, 1937.

The history and descriptions of the mines however, are of considerable interest. Greater activity existed in gem mining in California for a number of years than in any other State in the Union. Bulletin No. 37 of the State Mining Bureau, "Gems, Jewelers' Materials, and Ornamental Stones of California," by Dr. George F. Kunz, published 1905, was written during the height of activity in the tourmaline-kunzite-beryl-garnet area in San Diego and Riverside counties.

[2] "The first discovery of colored gem-tourmaline in the State goes back as far as 1872, when Mr. Henry Hamilton, in June of that year, obtained and recognized this mineral in Riverside County, on the southeast slope of Thomas Mountain. These colored tourmalines, now found at a number of points, were not encountered by Professor Goodyear,[3] who particularly noted the black tourmalines in the pegmatite veins, in his geological tour through San Diego County, in the same year, referred to above; but his reconnaissance was a little south of the gem-tourmaline belt. Some mining was done at this point, and fine gems were obtained. In the course of years three localities were opened and more or less worked in this vicinity, so that in the author's report on American gem-production for 1893, the following statement appeared:[4]

"Tourmalines are mined at the California gem mine, the San Jacinto gem mine, and the Columbian gem mine, near Riverside, California. These three mining claims cover the ground on which the tourmaline is found, and are situated in the San Jacinto range of mountains in Riverside County, California, at an altitude of 6500 feet, overlooking Hemet Valley and the Coahuila Valley, and 27 miles from the railroad. The formation in which the crystals are found is a vein from 40 to 50 feet wide running almost north and south through the old crystalline rocks which make up the mountain range. The vein in some places consists of pure feldspar, or else feldspar with quartz, in others all mica, and in others rose-quartz and smoky quartz. The tourmalines vary in size from almost micrograins to crystals 4 inches in diameter. They are most plentiful in the feldspar, but are found in other portions of the vein, sometimes in pockets and sometimes isolated. The larger crystals generally have a green exterior and are red or pink in the center. Some of the crystals contain green, red, pink, black, and intermediate colors; others again are all of uniform tint—red, pink, colorless, or blue. Associated with the tourmalines are rose-quartz, smoky quartz, asteriated quartz, and fluorite, and some of the quartz was penetrated with fine, hair-like crystals of tourmaline, strikingly like a similar occurrence of rutile.

"It may seem remarkable that this locality of gem-tourmalines should have been unrecorded in the earlier lists of California minerals given by such authorities as Professor Blake and Mr. Hanks in the reports of the State Mining Bureau for 1882 and 1884. But the parties who knew of the occurrence did not make it public for some years, and the earlier specimens were taken out quietly and their locality not divulged. The writer had positive knowledge as to the facts, however, and possesses a fine specimen obtained prior to 1873.

"The second important discovery in this region was made, or at least announced, twenty years later, in 1892, by Mr. C. R. Orcutt—the great locality of lithia minerals at Pala. Some illusions to red tourmaline from uncertain sources in this part of the State had appeared before; but nothing very specific. In the list of California minerals prepared by Prof. William P. Blake in 1880-82,[5] and also quoted in that of Mr. Henry G. Hanks, published in 1884,[6] references are made to the recent discovery of rubellite, for the first time in the State, associated with lepidolite, 'in the San Bernardino range, southern California.' The general description is precisely that of the Pala specimens, but the location is very indefinite. Mr. Hanks refers to the same association under lepidolite, and mentions a specimen in the State Mining Bureau, from San Diego County, and remarks that 'this may at some future time be found profitable to extract lithium from it' [7] a prediction abundantly verified now. Mr. Orcutt, however, was the first to make the locality known. It was noted by the author in his report for 1893, where the following account was given:[8]

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[2] Kunz, G. F., Gems, Jewelers' Materials and Ornamental Stones of California, State Mining Bureau, Bulletin 37, pages 21-25, 1905.

[3] Goodyear, W. A., San Diego County, State Mineralogist's Report, VIII, pages 516-522, 1888.

[4] Kunz, George F., Min. Res. U. S., Rept. U. S. Geol. Survey, 1893, p. 18 (reprint).

[5] State Mineralogist, 2d Rept., 1880-82, p. 207, Appendix.

[6] *Ibid.*, 4th Rept., 1884, p. 389.

[7] State Mineralogist, 4th Rept., 1884, p. 254.

[8] Rept. U. S. Geol. Survey, 1893, Min. Res. U. S., pp. 17, 18 (reprint).

" 'Mr. Charles Russell Orcutt has announced a new and remarkable occurrence of pink tourmaline in lepidolite, similar to that of Rumford, Maine, 12 miles south of Temecula, near San Luis Rey River, in San Diego County, the southern county of California, and it has already become celebrated from the abundance and beauty of the specimens yielded, as much as twenty tons having been sent East for sale.'

* * * * *

"The next important discovery was made six years later, in 1898; this was the wonderful Mesa Grande locality, some 20 miles southeast of Pala. There are various stories about the Indians having known it for many years, and the most familiar account is that given further on under Tourmaline. But the fact that some of the highly colored crystals are found in Indian graves in the vicinity, suggests that they may have been known and valued perhaps for a very long time. The ledge in which they occur is exposed by erosion on the side of the mountain; and the natives had certainly learned where to find crystals, and had them in their possession for some years before the whites knew anything about them. It is even said and they had learned how to do a little rude blasting, and thus to reach the cavities in which the minerals occur. It was not until 1898, however, that this now famous locality was made known to the world.

* * * * *

"For several years, these above noted were the only gem mines of this region, and their product was highly esteemed. But in 1902 began a succession of new discoveries that have attracted great attention. On Pala Chief Mountain and on Heriart Mountain began to be found not only fine-colored tourmalines, but the novel and remarkable gem-spodumene, designated as kunzite. This last-named mineral was found by Mr. Frederick M. Sickler, at what is now known as the White Queen mine, on Heriart Mountain, east of Pala, early in 1902; it is claimed, indeed, that he had obtained one or two pieces some time before, but it was not identified. In July, 1902, Mr. Sickler visited San Diego and Los Angeles, and showed specimens to local jewelers and collectors, none of whom recognized it. The first determination was made by the writer, from specimens sent by Mr. Sickler early in 1903.

"The great Pala Chief mine, which has given its name to the middle one of the three ridges or mountains at Pala, and has yielded magnificent tourmalines and the largest and finest gem-spodumene crystals was located in May, 1903, by Frank A. Salmons, John Giddens, Pedro Peiletch, and Bernardo Heriart. The actual discoverers were probably the two last named, the Basque prospectors who had already been working and locating claims with the two Sicklers, father and son, on Heriart Mountain, the ridge a little to the east. Mr. Salmons has been the principal operator, however, of this very notable mine.

* * * * *

"Meanwhile, on September 8, 1902, gem-tourmaline had been discovered on Aguanga Mountain, some 5 miles south of Oak Grove, by Mr. Bert Simmons. This locality lies nearly east from Pala and south from that at Coahuila, next to be mentioned, and about equally distant from the two, some 15 miles. Kunzite has since been found on the same claim.

"On May 30, 1903, Mr. Simmons discovered both colored tourmalines and kunzite in Riverside County, some 10 miles west of the old Hamilton (first) discovery. The locality is on Coahuila Mountain, about 20 miles northeast of Pala. The mine was for some time known as the Simmons mine, but has been sold to Mr. E. A. Fano, of San Diego, and is now called by his name. This is one of the most promising and productive mines of the region.

"The discoveries at and around Ramona followed in rapid succession, in 1903. Some had been made several years earlier, but they had not attracted much notice. Essonite garnet was reported near Ramona in 1892, by D. C. Collier, and also fine epidote. Much of the essonite found hereabout is of rich color and fine gem quality.

"Several mines, with this 'hyacinth' variety of garnet and more or less of beryl and tourmaline, were located in May, July, and September, 1903.

"On October 3d of that year, topaz was discovered in the same vicinity, by James W. Booth and John D. Farley. This was a novel and important addition to the gem products of the State. The crystals are of various sizes, some of them large, often transparent, and range from colorless to pale shades of blue, much resembling those from the old and well-known locality at Sarapulka in the Ural Mountains."

NATIVE ELEMENTS

NON METALS

DIAMOND

Diamond, C

H. 10; Sp. Gr. 3.5±; Refractive index, n = 2.4175

The diamond besides being the gem stone of highest value and importance, is also indispensible for a number of industrial purposes.

Soon after the discovery of gold in California, diamonds were found as a constituent of the auriferous gravels. Lyman (1) reported seeing a pale-yellow crystal about the size of a pea which had been recovered from the river gravel. A few years later they were found in the gold-bearing gravels at Cherokee, Butte Co., which locality has yielded the largest number of diamonds found in the state. Placer deposits in other parts of the state have also yielded them from time to time as the diamonds are not restricted to any one locality. Although no systematic records have been kept, between four and five hundred stones have been found. Most of them were small, of a pale yellow or straw color, though a few have been found exceeding two carats in weight and of good quality and colorless.

The origin and source of these diamonds is still unknown. It is presumed that their genesis has been in the basic igneous rocks from which the serpentines of the gold regions have been derived and through continued search they may yet be found in place. The discovery near Oroville of an apparent pipe of serpentinized rock resembling the South Africa deposits led to some active operation by the U. S. Diamond Mining Co. A shaft was sunk but operations were not successful. The rock is a hard eclogite.

Hanks (1) gives an interesting account of the diamonds found in the early days of gold mining, and Storms (1) also contributed short articles on California diamonds.

In 1867 Prof. Benjamin Silliman, Jr., exhibited several diamonds before the California Academy of Sciences which were found in various districts, Cherokee in Butte Co., Fiddletown, Amador Co., one from El Dorado Co., and another from French Corral, Nevada Co.

Most of these were obtained from the ancient-river gravels. Prof. Josiah D. Whitney listed some fifteen localities here and states that the largest stone he had seen weighed 7.25 carats.

A total of eight counties have yielded diamonds, Del Norte, Trinity, Plumas, Butte, Nevada, El Dorado, Amador and Tulare. The greatest number however have been found in Butte, El Dorado and Amador counties, Nevada County having produced the largest stone as above mentioned.

The Volcano district in Amador Co., has yielded a number of stones, one of the largest, a pale straw-colored stone weighed 1.25 carats. Butte Co., is noted principally for the Cherokee district and diamonds have also been found at Yankee Hill and at Oroville.

El Dorado has several localities near Placerville. Turner (1) states most of the stones have been found south of Smiths Flat and at White Rock Canyon as well as Webber Hill.

In part the gold-bearing gravels which contain the diamonds is a conglomerate or cemented gravel, and in order to recover the gold the gravel is crushed and milled, so that whatever diamonds are contained therein are crushed also. The diamonds are so sparsely distributed that it is exceedingly doubtful if efforts to recover them would prove profitable.

In 1882 a beautiful stone weighing 1.57 carats was found at Volcano. This stone is a modified octahedron with curved faces and edges. This example of California diamond may be seen at the Museum of the State Division of Mines in the Ferry Building.

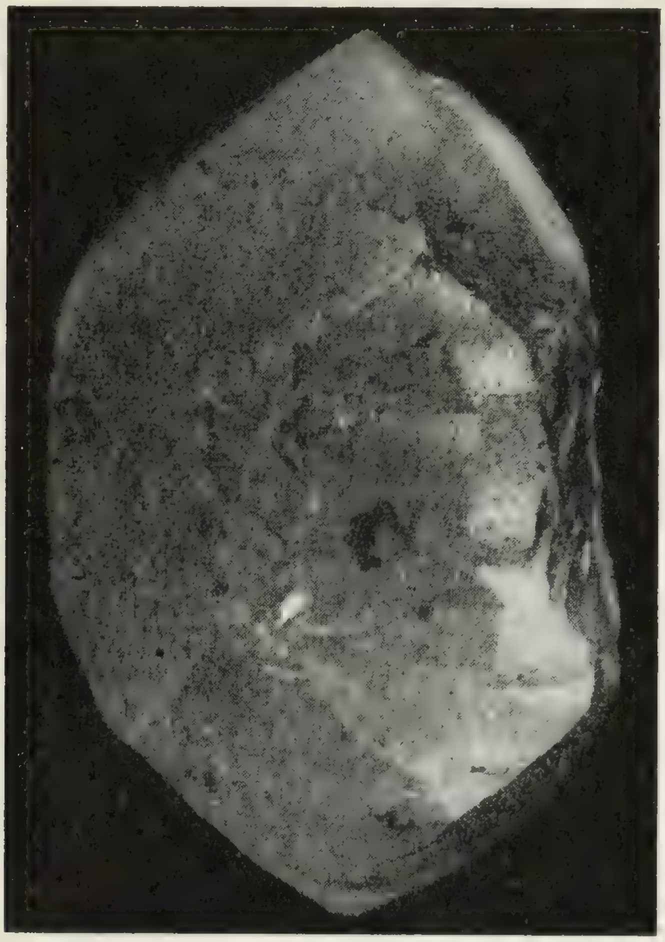

Photo by G. Dallas Hanna

FIG. 1. Diamond found, 1934, near Plymouth, Amador County. Enlarged 8X. Weight 0.53 grams (2.65 carats); maximum length 8.5 mm.; maximum width 6.1 mm.; minimum width 5.7 mm.

The Cherokee District in Butte County has long been famous for the number of diamonds found. A fine crystal found in the Spring Valley Hydraulic Mine was presented to the Museum by Mr. Williams, superintendent of the company. Two large stones were found which when cut yielded stones weighing 1.50 and 1.187 carats respectively.

In El Dorado County about three miles east of Placerville diamonds were found in the auriferous gravel. In 1871 an examination of the gravel was made by N. A. Goodyear, assistant State Geologist, who upon finding specimens of Itacolumite expressed an opinion that diamonds should be found in the gravel. A vigorous search disclosed a number in the possession of some of the miners, none of whom knew their true nature. In 1894 W. P. Carpenter of Placerville announced the acquisition of two crystals weighing six and seven troy grains respectively.

After the introduction of the stamp mill in place of the sluice box the recovery of diamond crystals decreased. From time to time

shattered fragments have been found in the tailings, mute evidence that the diamonds still exist.

In Nevada County diamonds have been found at French Corral, one yellowish stone weighing 1.60 carats being exhibited by Silliman. The largest stone found weighing 7.25 carats was from this district.

The black sands of Trinity River which drains through Trinity County in the northern part of the state has yielded microscopic diamonds.

METALS

GOLD, SILVER, PLATINUM, IRIDIUM, PALLADIUM, IRON

GOLD

Native Gold Au.

H. 2.5–3.0; Sp. Gr. 15.6–19.3.

Gold has always been the most important metal in the jewelry industry and its use is extensive. From earliest times in Egypt and Babylonia to the present this beautiful yellow metal has been wrought into exquisite works of art. The use of nuggets for jewelry purposes is extensive, small pieces are usually worked into chains, pins, rings and bracelets while the larger pieces are used as solitaire mountings or as pendants.

Gold Quartz has long been the most prominent gem mineral of the state. Most of the quartz found contains gold in such finely distributed particles as to be invisible. At times however it occurs in dense concentration in spots, flakes and moss-like markings throughout the quartz and when cut and polished makes handsome gems. Sometimes quite large water-worn boulders rich in gold are found. One large boulder found by the Nevada Hydraulic Co., weighed 160 pounds and contained about $2,500 worth of gold. Two small boulders weighing about one pound each, when cut yielded several dozen fine stones. While most of the quartz is white or nearly so, at the Sheep Ranch Mine in Calaveras County a black quartz is found. This when cut with the bright yellow gold showing forms beautiful gems.

The gold fineness varies considerably, the average of the better type being .875 fine or about 21 Kt. Gold quartz is extensively used for inlaying in boxes, frames, watch chains, pins and brooches and in cabochon sets for rings, clips, brooches, pendants and other classes of jewelry.

Gold has always been one of the most important mineral products of the state and has a wide distribution throughout it, being found in every county and produced in two-thirds of them.

Although gold is known to have been mined by the Indians in Los Angeles County as early as 1841, Symons (1), it was not until 1848 with its discovery at Coloma and the world-wide publicity given which led to its rapid development and production, in 1852 reaching an all-time high—record value of $81,294,700. This great quantity of precious metal was recovered principally from the gold-bearing gravels of the river streams and ancient-river channels throughout the state.

Many valuable nuggets and masses of large size were found. In 1854 at Carson Hill, Calaveras Co., one large specimen weighing

2,340 Troy ounces was found and in 1860 another weighing 1,596 Troy ounces was found at the Monumental mine, Sierra Buttes. Hanks (2) records many other nuggets which were found in the early days.

Gold is not confined to one class of rocks, although the gold-bearing quartz veins are principally in metamorphic schists and slates. The original source of the gold has been the igneous rocks and it is found in granites, syenites, monzonites, granodiorite, diorite, rhyolite, quartz-porphyries, andesites, porphyrites and diabases.

With quartz it has been deposited or impregnated in metamorphic rocks such as gneisses, amphibolites, chlorite schists, talc schists, mica schists, slates and quartzites and sedimentary conglomerate, sandstone and shales.

Gold in quartz is the usual association and although numerous localities have produced high-grade ore showing moss-like concentration of gold in quartz, the bulk of the regular production contains the gold in such finely divided particles as to be invisible. Gold in pyrite or 'auriferous pyrite' is widely distributed, and with it galena is frequently associated. From this type of ore the bulk of the gold is produced.

Gold is also associated with many other minerals. In arsenopyrite it is common throughout the Mother Lode, also in the Alleghany district, Sierra County. To a lesser degree, gold is found in calcite, and barite as gangue minerals and in a few localities it has been found with cinnabar. In addition it has also been observed in a wide variety of minerals, Eakle (1).

The leading gold-producing counties in the state are Amador, Butte, Calaveras, El Dorado, Kern, Mariposa, Nevada, Placer, Sacramento, Shasta, Siskiyou, Sierra, Trinity, Tuolumne and Yuba.

SILVER

Native Silver, Ag.

H. 2.5–3 ; Sp. Gr. 10.5±.

Silver is extensively used for jewelry purposes and for ornamental articles and has universally been used from the earliest times.

Native silver has not been found in any large masses in California, yet the element is universally present in the gold and copper-producing areas and occasionally arborescent masses, wires and thin sheets are found in the mines producing these metals. It is more common in the silver-lead districts, where it occurs often near the walls of veins or in the vicinity of intrusive dikes, as a reduction product.

The metal is produced in the following counties. Alpine, Calaveras, Inyo, Kern, Los Angeles, Mono, Nevada, Placer, Plumas, San Bernardino, and Shasta.

Although Inyo County is a typical silver producer having many celebrated mines and districts such as the Cerro Gordo and the Kearsarge, most of the silver produced in the state comes from the gold-producing districts and is recovered with the extraction of the gold. Of forty-three counties producing silver, five counties produced 86 per cent of the total, 66 per cent of which came from gold-bearing ores.

COPPER

Native Copper, Cu.

H. 2.5–3 ; Sp. Gr. 8.83.

From earliest times copper has been used for arts and for personal adornment. Today it is a popular medium for the design of art-craft jewelry and may be used in combination with silver or gold.

Shaku-do is an alloy extensively used by the Japanese for inlay work, being composed of 8% to 10% gold and the balance copper. With age it takes a beautiful purple-brown color which is most attractive.

While most of the copper mines in the state have produced native copper, no distinct deposits of the native metal are known. Where found in the mines it has been reduced from the ores through the intrusion of dikes and is also found as coatings along the walls of veins. Sometimes it is found together with malachite and cuprite.

From 1896 to 1932 copper was the most important metal produced next to gold, the maximum production was in 1909 with 65,727,736 pounds and in 1916 due to higher prices prevailing the value of the total output reached $13,729,017, Symons (1).

Copper has been produced in twenty-seven counties the more important occurrences of the native metal being:

El Dorado County. The Cosumnes mine near Fairplay, the Alabaster Cave mine near Newcastle, the Cambrian mine near Placerville, the Ford mine near Georgetown and the Oest mine near Auburn.

Mariposa County. The Copper Queen mine.

Placer County. At the Algol mine near Spenceville, Valley View mine near Lincoln and in the Ophir district.

Plumas County. With rhodonite at Mumford's Hill; and with cuprite, malachite and native silver in the Pocahontas mine, Indian Valley.

Shasta County. This was for some years the principal copper county and many of the mines have produced specimens of aborescent copper and occasionally compact masses. Some of the mines are, Bully Hill, Copper City, Shasta King, Greenhorn, Mountain Copper, Mammouth, Balaklala, and Kosk Creek.

PLATINUM

Native platinum, Pt.

H. 4–4.5 ; Sp. Gr. 14–19.

For several decades past platinum has become increasingly popular for jewelry purposes, and for the higher classes of jewelry it has completely supplanted gold. Occasionally the natural nuggets are mounted for stick pins or other jewelry.

Early in California's history gray metallic grains and small nuggets of platinum were observed in some of the gold-bearing black sands of the streams and beaches and also in the concentrates from gold washings. Little attempt was made to save this metal and it is only in recent years that records have been kept of production.

It is found throughout the gold-bearing districts and the bulk of the production is obtained as a by-product in the dredging for gold. Platinum is practically always found in combination with iridium, palladium, osmium, rhodium, and ruthenium. Nuggets up to an ounce or more have been found.

IRIDIUM

Native Iridium, Ir.

H. 6–7; Sp. Gr. 22.6–22.8.

Iridium is extensively used as a hardening agent in platinum for jewelry purposes. The best type of alloy contains 10 per cent iridium and 90 per cent platinum. In the Trinity River and New River districts in Trinity County, most of the 'platinum' nuggets are osmiridium (iridosmine).

PALLADIUM

Native palladium, Pd.

H. 4.5–5; Sp. Gr. 11.3–11.8.

Due to its lower cost an effort has been made to use this metal in place of platinum. It is found naturally alloyed with the other metals of the platinum group.

IRON

Native Iron, Fe.

H. 4–5; Sp. Gr. 7.3–7.8.

Iron has been used for centuries past for rings and there is a belief that it has curative properties, especially for rheumatism.

During the past decade many fine pieces of iron jewelry have been produced. These articles as fabricated by one manufacturer are cast and after finishing in the usual way are sand blasted and then oxidized to a beautiful velvety jet-black finish, the like of which is impossible to produce on any other metal. Set in combination with ox-blood coral, lapis lazuli, jade or pearls the effect is unusual and artistic.

Iron occurs native either as telluric iron or as meteoric iron. Meteoric iron has been found in at least four localities in California. Analyses show that nickel is always present and sometimes cobalt, phosphorous, graphite or diamond.

A meteorite weighing 85 pounds was found at Shingle Springs, El Dorado County in 1871. One found in the San Emigdio Mountains in Kern County in 1888 weighed about 80 pounds. In San Bernardino County near Ivanpah, in 1880, an irregular-shaped mass of meteoric iron was found which weighed 117 pounds and at Canyon City, Trinity County, a mass weighing about 19 pounds was found in 1875.

Small grains have been found in the gold-bearing sands of Smith River in Del Norte County.

SULPHIDES

PYRITE—'Iron Pyrites'

Sulphide of iron, FeS_2.

H. 6–6.5; Sp. Gr. 5.

Pyrite is extensively used as a gem stone in inexpensive jewelry. When cut into small round stones having a series of triangular facets evenly distributed over the crown and having a flat back, (Rose Cut) it is called 'Marcasite' and these are set in cheap jewelry of all kinds.

Pyrite is the commonest of the sulphide minerals and is found in all kinds of rock but is particularly prominent in the metamorphic

schists, slates and quartzites and in unaltered sandstones. Although it is found in combination with other minerals it sometimes is found in crystals up to several inches in diameter. Its occurrence in California is widespread.

HALOIDS

FLUORITE

Fluoride of calcium, CaF_2.

H. 4, Sp. Gr. 3.2; Refractive Index, $n = 1.434$.

Fluorite is a common mineral. It sometimes forms thick veins and plays an important commercial role as a flux. In the finer grades it is widely used as an ornamental object. The Chinese are masters of the art of carving and fluorite is a popular medium in which to express this artistry. Birds, statues, desk sets and objects of all kinds including dishes and bowls are made from it. It is also used in optical instruments.

Fine crystals of green and purple fluorite are found in the following counties: Los Angeles, Mono, Riverside, San Bernardino, and San Diego.

OXIDES

OXIDES OF SILICON

QUARTZ-Silica

Oxide of silicon, SiO_2.

H. 7; Sp. Gr. 2.65; Refractive Indices, $N_\gamma = 1.553$, $N_\alpha = 1.544$.

Silica is one of the most widely distributed minerals and constitutes about three-fifths of the earth's crust. The silica minerals are classified under two groups. Under *Quartz* are classed those forms which are phenocrystalline, that is those with a distinct crystal structure; and under *Chalcedony*, those which are cryptocrystalline, that is those so finely crystalline that they appear non-crystalline except under the microscope.

Common quartz is an essential constituent of granites, granodiorite quartz-porphyries, rhyolites, gneisses, schists, quartzites and sandstones. Veins, seams and masses of white quartz are common in volcanic and metamorphic areas and in California much of it is gold bearing.

QUARTZ—Crystalline

Rock Crystal (colorless)	Asteriated Quartz (with star)
Amethyst (all shades of purple)	Aventurine (spangled)
Citrine (yellow)	Quartz Cat's Eye (fibrous)
Smoky Quartz (smoky brown)	Gold Quartz
Cairngorm (dark brown)	Tourmalinated Quartz (tourmaline incl.)
Spanish Topaz (deep yellow to brown)	Rutilated Quartz (rutile incl.)
Rose Quartz (rose)	Thetis Hairstone (rutile incl.)
Morion (black)	Phantom Quartz

Clear transparent colorless quartz known as 'rock crystal,' although widely distributed throughout the state, is rarely found in large size; it is usually found in clusters and groups lining cavities and in seams and veins in igneous rocks and is recovered as an accessory mineral in the mines. From time to time unusual deposits have

been found and worked due to demand for the material. In 1891–92 an excellent deposit was found near Placerville, El Dorado County, in a decomposed vein material of reddish earth, fine rock-crystals varying in size and weight from a few ounces to over eighty pounds. Many were clear and limpid, some over fifty pounds in weight. Some contained inclusions of chlorite in successive stages forming beautiful phantom crystals.

The most extensive deposit of rock crystal in California was found in 1897 by John E. Burton of Milwaukee, Wisconsin, at the old Green Mountain Mine, Calaveras County, one and one-half miles south of Mokelumne Hill. Here in an ancient-river channel filled with auriferous gravel a quantity of enormous quartz crystals were found. A number of tons of crystals were removed, one attached to a group of 47 smaller pieces weighed over a ton. A number of the finest were sent to New York and crystal balls were cut from them by Tiffany & Company. One of the largest crystals measured 19x15x14 inches and one other 14x14x9 inches. A perfect sphere measuring five and one-half inches in diameter valued at $3,000 was cut from one of these crystals. Larger spheres have been cut from California crystals to over 7 inches in diameter, but none were perfect. Some of these crystals were the largest ever found.

In recent years this deposit has produced many tons of quartz although much of this is flawed and feathered and massive but a small amount being suitable for gem purposes. The widespread use of quartz for oscillators for radio apparatus has led to extensive search for commercial deposits. Prices range to $3.00 per pound for clear pieces two to five pounds each in weight.

Many counties produce fine specimens, a few important localities follow:

Calaveras County. Green Mountain Mine.

Amador County. Has produced fine large specimens from Volcano and Oleta.

El Dorado County. At Placerville and at White Rock Canyon near Georgetown.

Nevada County. Good specimens of rock crystal are found at Grass Valley and Nevada City. Large specimens have been found near Washington.

Placer County. Rock crystal occurs in the Ophir district.

Riverside County. Rock crystal in fine large crystals have been found at Coahuila.

San Diego County. Excellent specimens have been found in the tourmaline gem mines of the county.

AMETHYST

Amethyst is transparent crystalline quartz of various tones of purple varying from light to dark.

Few deposits are known in the state. Pale violet-colored amethyst has been found in Lake Co., the Clear Lake Gem Mining Company, Woodland, California, J. F. Garrette, Mgr., has operated a deposit near Howard Springs. This material shows remarkable metamorphism being found only in fragmentary pieces. Fragments showing

original crystal faces are rare. The material polishes into brilliant light-colored stones.

Mono County has produced amethyst from the Bodie district.

San Benito County. A few crystals of fair color were found in the San Carlos Mine of the New Idria Quicksilver Company.

CITRINE, SPANISH TOPAZ, CAIRNGORM, SMOKY QUARTZ, MORION

These transparent varieties of quartz, vary in color from light yellow through all of the tones of brown to black. Citrine and Spanish Topaz are the type commonly sold by the jeweler as 'topaz.' The darker shades of smoky quartz may be lightened by careful heating or the color may be removed altogether. Cairngorm is also known as 'scotch topaz,' and Smoky Quartz as 'smoky topaz' and 'smoky crystal.'

Yellow crystals have been found at the Newman mine on Cedar Mountain near Livermore, Alameda Co., and at Bald Mountain in Sierra County.

Smoky quartz is widespread and many fine specimens have been found in many localities. It occurs in the following counties:

Amador, in the Volcano and Oleta districts; Butte, on the North Fork of Feather River; El Dorado, near Placerville; Riverside, at Coahuila, Rincon and Mesa Grande; San Diego, in the various gem mines at Pala and Ramona.

ROSE QUARTZ

Rose quartz is practically always found massive, although crystals have been found. Several fine deposits exist in the state and it is found in the following counties:

Alpine County. In Hope Valley and in the Mogul and Monitor districts.

Amador County. At Volcano and Oleta.

Butte County. Near Forbestown.

Plumas County. Deep-colored rose quartz has been found in Meadow Valley.

Riverside County. At Coahuila.

San Diego County. Single crystals of a deep-rose color has been found in the pegmatites in which the other gem minerals are found as well. An opalescent rose-quartz occurs at Escondido.

Tulare County. Rose quartz is found at Bull Run Meadows and at Yokohol; beautiful specimens are found at the Summer Rose Quartz claim eight miles south east of California Hot Springs near Kern County line. It is also found on the west side of Bull Run Ridge; near Lemon Cove and at Badger. Excellent material is found in a pegmatite on the Gasenberger Ranch near Exeter.

Asteriated quartz, aventurine, tourmalinated quartz, rutilated quartz, and *thetis hairstone* as well as *gold quartz* are all varieties of quartz and with the exception of asteriated quartz, always contain inclusions which may be hematite, mica, chlorite, tourmaline, rutile, asbestos, actinolite or gold.

These varieties are associated with those above mentioned and are found in the following counties. Amador, thetis hairstone near Oleta; Butte County, tourmalinated quartz, the tourmaline being in brilliant-

black hair-like crystals. El Dorado County, phantoms at Placerville, with chlorite; rock crystal with actinolite inclusions are found near Fairplay.

Los Angeles County. Thetis hairstone near Los Angeles.

Placer County. Rock Crystal with green chlorite at Shady Run.

San Bernardino County. San Bernardino Range, quartz with rutile needles; also with specular hematite and epidote in the San Bernardino Mountains 30 miles northeast of San Bernardino.

San Diego County. Tourmalinated quartz found on the east side of Chihuahua Valley.

CHALCEDONY

Silicon dioxide SiO_2.

Refractive Indices, $n_\gamma = 1.543$, $\alpha = 1.532$.

The chalcedony forms of quartz are never transparent but occur in dense cryptocrystalline masses, translucent to opaque in a wide variety of colors and without crystal form. Hot solutions especially alkaline solutions acting upon silica in rocks dissolve some of the silica which is redeposited in layers, in seams or cavities in rocks completely or partly filling them, forming geodes and irregular-shaped masses, often with a banded structure. Chalcedony is a common secondary filling in cavities and fissures, in volcanic rocks and may form large geodes. In this manner often huge deposits of chalcedony and jasper are formed by deposition from springs whose waters contain soluble silica.

Chalcedony is more widely distributed than quartz and is found in large deposits. The various forms of chalcedony may differ slightly or markedly in color, pattern and texture. These include:

Chalcedony (white, blue, brown—pale tints)
Carnelian (flesh pink to red)
Sard (dark red to red brown)
Sardonyx (red and white layers)
Chrysoprase (green)
Agate (banded, various colors)
Onyx (black, or black and white striped)
Moss Agate (moss-like inclusions)
Jasper (opaque red, brown, green, etc.)
Bloodstone (dark green chalcedony with red jasper spots)
Agate Jasper (combined)
Basanite (black jasper)
Silicified Wood (Petrified Wood)
Myrickite (cinnabar in chalcedony)
Kinradite (spherulitic jasper)

Many fine specimens of all varieties have been found in the state. On the beaches along the Pacific Ocean, as well as in the stream beds or lake shores, chalcedony, agate or jasper pebbles are found in the greatest profusion. Notable deposits on the ocean beaches are: At Crescent City, Del Norte County in the northern part of the state. At Pescadero in the central part about 25 miles west of San Jose, chalcedony and agate pebbles are abundant. Occasionally hollow chalcedony pebbles containing liquid are found, (*hydrolite*). At Redondo, a beach resort 15 miles south of Los Angeles, fine pebbles are found. These are cut by the local lapidaries and are prized by the tourists. At Moonstone Beach, Santa Catalina Island, many chalcedony pebbles are found. On the shore of Lake Tahoe, agate, chalcedony and jasper pebbles are abundant, many of which are finely marked.

A sky-blue to deep-blue variety found near Kane Springs, Kern County is highly prized, this variety is sometimes called 'sapphirine'. In ancient times this type of chalcedony was highly prized by the

Babylonians and was extensively used for sealing purposes, the material being cut in the form of a cylinder and the engraving cut into the surface. The California deposit occurs in a reddish rhyolite which is sometimes cut with it. The chalcedony is usually in geodes or nodules and often fine picture effects are to be had by sawing these in half and polishing.

Chalcedony is also noted in Alameda County, as small geodes in the Berkeley Hills.

Imperial County. Fine agates are found as drift pebbles in the Colorado Desert near Canyon Springs.

Marin County. The beach pebbles at Bolinas are agate and chalcedony. Beautiful small carnelian pebbles, (amygdules) are found about two miles north of Point Bonita.

San Bernardino County. Moss agate has been found in the San Bernardino Mountains; bluish chalcedony occurs in the Black Mountains north of Barstow. White to creamy-white chalcedony with inclusions of hematite forming graphic markings (graphic chalcedony) occur near Barstow.

Myrickite occurs 45 miles northeast of Johannesburg and 15 miles northeast of Lead Pipe Springs; also in several of the quicksilver mines of the state, notably in the Rinconada Mine, San Luis Obispo County. Fine blue chalcedony is found two miles northeast of Lead Pipe Springs. Bloodstone is also found near here.

San Diego County. Red and white-banded chalcedony is found southeast of Dulzura and east of Donohoe Mine. Amethystine to pale-violet chalcedony found east of San Diego has been called 'violite.'

Tulare County. Fine moss-agate is found in Deer Creek. Chrysoprase is found in the hills east of Visalia on Deer Creek and at Yokohol. It was mined at Venice Hill, Stokes Mountain, Tule River, Deer Creek and one mile east of Lindsay.

Onyx

Very little true onyx is found in the state. Thick banded masses often of large size are found at the Knoxville quicksilver mine in Napa County.

The 'black onyx' sold by the jeweler is a chalcedony artificially colored by chemical means.

Bloodstone is green chalcedony having included spots and markings of red jasper. Fine bloodstone is rare, most of the material found and so termed is mottled or variegated green and red jasper.

Chrysoprase

Chrysoprase is a beautiful apple-green chalcedony, deriving its color from nickel compounds. It has been prized from ancient times and is sparsely distributed, few localities being known. Several localities exist in Tulare County, near Visalia. The first discovery was made in 1878 by a surveyor, George W. Smith. Mr. Max Braverman who was a collector of some note identified the mineral as chrysoprase. The original locality is at Venice Hill about 12 miles northeast of Visalia, where the material is found in thin veins. Much of it is flawed and cloudy but many fine dark apple-green colored stones were found.

Other deposits were found, five in all, one on Stokes Mountain, another on Tule River. The fourth on Deer Creek was found in 1897, thirty miles southeast of Visalia.

The following year another deposit was discovered at Lindsay. Associated with this material is a green opal which is called 'chrys-opal' or 'opal prase'. There was considerable activity in these mines after their discovery, over two thousand pounds being mined the first year. In the early part of the present century, a large New York company operated the mines and by 1902 the production had reached a value for that year of $15,000. For some time past the mines have been inoperative and only small quantities reach the market.

Jasper

Jasper is one of the most abundant varieties of cryptocrystalline quartz and it is widely distributed throughout the state. Many different types are found. These are characterized by solid or variegated colors of all kinds and patterns and is always opaque. The color is due to impurities, usually iron compounds which vary considerably in content. This jasper ranges in quality and texture from fine close-grained solid material differing little from chalcedony to coarse friable material commonly known as chert.

Jasper pebbles are found in practically all river streams, on the shores of lakes and along the ocean shore. It is common in the Franciscan series and is profusely distributed on both shores of the Golden Gate. An interesting variety called *Kinradite* is found here in the basalt and as loose pebbles and masses, being composed of spherulites, colored red by iron oxide. Sometimes the matrix is dark green and when cut with the red spots in contrast makes beautiful stones. The majority of the jasper found is in uniform and variegated colors of red, brown, yellow, green, and white.

Sometimes deposits of jasper reach large proportions. At Stone Canyon in Monterey County, 16 miles east of Bradley, a deposit of this type occurs. Here a fine-grained breccia is found. The deposit contains several thousand tons, many boulders lying about being individually several tons in weight. The dominant color of the jasper here is tan and brown and the breccia is cemented with chalcedony varying in color from white, through blue, purple, brown and black.

A beautiful orbicular jasper is found in Santa Clara County near Morgan Hill. The prevailing color is a brick-red having orbicular markings in yellow and maroon. Angular markings are also present and the stone is one of great beauty. Boulders over 100 pounds in weight have been extracted. Wm. B. Pitts of Sunnyvale, an ardent collector, has done much to popularize this material. His collection is both extensive and educational as well, many examples of orbicular jasper being included.

'Agate jasper' is a combination of chalcedony with particles of jasper and is found with the other quartz forms.

Basanite is a black variety. Fine specimens have been found along the Ocean Beach from San Francisco to Mussel Rock in San Mateo County. It is commonly called 'touchstone' and is used for testing gold by streak and acid reaction.

PETRIFIED WOOD—Silicified Wood

Petrified (silicified) wood is a most interesting mineral. This is a pseudomorph of silica replacing the wood. In fine specimens the entire wood structure may be clearly seen, the general form of the tree trunk, bark and concentric rings. Under the microscope the fine cellular structure which is perfectly preserved may be readily discerned and the type and class of wood determined. Some pieces of unusual academic interest are found showing a gradual change from wood right through to silica or opal. Petrified wood is found in one notable locality, the Petrified Forest, Sonoma County, west of Calistoga. Here large masses are found in place, tree trunks varying in diameter from one to five feet and up to 100 feet in length being embedded in the ground and have been uncovered. The color is usually tan or light-brown and the grain of the wood is quite distinct, chalcedony may be found filling seams and cracks. Most of the material is porous and is not capable of receiving a high polish like the silicified wood from other localities.

Fragmentary pieces of silicified wood are also found in the gravels of the hydraulic mines in northern California. The majority of the specimens found however are opalized.

Opalized wood is rather common and is found throughout the gold regions. The trees which grew along the banks of the ancient rivers were buried under rock, mud and lava and in the countless ages since, through the infiltration of siliceous waters, silica was deposited and replaced the wood fibers, retaining the original form and structure. Colors range from white through the shades of yellow and brown to black. Wood opal is capable of receiving and retaining a high polish and is extensively used for ornamental purposes.

OPAL

Hydrous oxide of silicon, $SiO_2.nH_2O$.

H. 5.5–6.5 ; Sp. Gr. 2.1–2.2 ; Refractive index, $n = 1.406–1.460$.

Opal differs from chalcedony in being amorphous and carrying varying amounts of water. It is silica which has solidified from a colloidal state. It commonly occurs in cavities and seams in many kinds of rocks.

Precious opal shows a beautiful play of colors.

Common opal is widely distributed and is found in a variety of colors.

Hyalite is a glassy transparent type and is found occasionally in the cavities of volcanic rocks.

Chrysopal, 'prase opal' or 'opal prase' is a green type closely resembling chrysoprase.

Moss opal is common opal showing moss-like markings or inclusions.

Wood opal is wood replaced by opal.

All of the types of opal are found in the state and are used for gem purposes. Precious opal and prase opal are rare while common opal is abundant. The latter material is found throughout the Mother Lode in large masses buried in the ancient-river channels. Opal of gem quality has been found in the following counties.

Napa County. Opal-prase occurs at the Knoxville mine.

San Bernardino County. Some good opal of gem quality occurs in the Black Mountains about 25 miles north of Barstow.

Siskiyou County. Fire opal has been found near Dunsmuir.

Sonoma County. Some opal of gem quality has been found near Glen Ellen. Fire opal has been found in a clay deposit on the Weise Ranch between Glen Ellen and Kenwood.

Tulare County. Opal-prase is found in the chrysoprase deposits in the hills east of Visalia and Porterville.

OXIDES OF THE METALS

ANHYDROUS OXIDES

Cuprite	Ilmenite
Corundum	Spinel
Hematite	Cassiterite

CUPRITE—Red Copper

Red oxide of copper, Cu_2O.

H. 3.5–4; Sp. Gr. 5.99; Refractive index, $n = 2.849_2$.

Cuprite is occasionally used for gem purposes and when pure and free from cracks is capable of receiving a high polish.

Cuprite occurs in most of the copper localities as a secondary mineral in the oxidized portions of the deposits. Massive specimens have been found in many counties but no large bodies of the mineral have been noted in California. Cuprite is found in the following counties, Eakle (1).

Alameda, Amador, Calaveras, Del Norte, Fresno, Glenn, Humboldt, Kern, Lassen, Modoc, Mono, Napa, Nevada, Placer, Plumas, Riverside, San Benito, San Bernardino, Shasta, Trinity, Tulare, and Tuolumne.

CORUNDUM

Oxide of aluminum, Al_2O_3.

H. 9; Sp. Gr. 3.95–4.10; Refractive indices, $n_\alpha = 1.760$, $n_\gamma = 1.768$.

Its great hardness and high specific gravity serve to distinguish corundum from other minerals. Transparent varieties as well as translucent to opaque asteriated corundum are important gem stones. *Ruby* is the name given red varieties and *sapphire* is applied to all the other colored varieties. Asteriated stones are those which exhibit a six-rayed star when cut cabochon and are called *Star Rubies* or *Star Sapphires* according to color.

Massive corundum is an important abrasive mineral. An impure form called 'emery' is extensively used for this purpose.

Corundum is a constituent of syenite rocks, a type which is not common in the state. In the few localities where it is found, it exists in limited quantities, consequently few corundum gem stones have been found.

Los Angeles County. First found in the state in the drift at San Francisquito Pass as small blue pebbles, W. P. Blake (1). Near Uplands red corundum crystals occur in a syenite in San Antonio Canyon.

Plumas County. Large crystals of a pale violet shade occur in the plumasite of Spanish Peak, Lawson (1).

San Bernardino County. Found in the Kingston Range. Rubies have been identified in limestone from the Baldy Mountains, but no stones of commercial size have as yet been taken out.

San Diego County. A constituent of the dumortierite schist of Dehesa, Schaller (1). Occurs in a vein with garnet in a mica schist on the north slope of San Miguel Mountains, 26 miles east of San Diego, in pink colors and opaque crystals.

HEMATITE—Red Ochre

Sesquioxide of iron, Fe_2O_3.

H. 5.5–6.5; Sp. Gr. 4.9–5.3; Refractive indices, $n_\alpha = 2.94$, $n_\gamma = 3.22$.

Hematite is the chief ore of iron and large deposits occur in California. Several distinct types are found, Eakle (1). Only the fine-grained material is capable of being highly polished. Hematite has been used as a gem from the earliest times. It was often used for intaglii in the early Roman days. When properly polished it possesses a brilliant luster and is often cut into the diamond form (brilliant cut) and sold as 'black diamonds,' the resemblance being quite marked. Intaglii in hematite are fashionable at the present time and make handsome ringstones.

Deposits occur in thirty-six counties. There are large deposits in Inyo, Madera, San Bernardino, and Shasta counties.

Other iron minerals found in the state and sometimes used for gem purposes are—

ILMENITE. Oxide of iron and titanium, $(FeTi)_2O_3$. Hexagonal rhombohedral. Plates, massive and in rounded pebbles and grains. Color black; streak dark-brown to black. Metallic luster. H. 5.6; Sp. Gr. 4.5–5.0.

CHROMITE. Oxide of iron and chromium, $FeCr_2O_4$. Isometric, generally massive; color black; streak grayish-brown. Metallic luster. Sp. Gr. 4.32–4.57. Refractive index, 2.16.

GÖTHITE. Hydrous oxide of iron, $Fe_2O_3.H_2O$. Orthorhombic; slender prisms, vertically striated; cleavage perfect brachypinacoidal. Color yellowish-brown; streak yellowish-brown; adamantine to submetallic luster H. 5–55; Sp. Gr. 4.37; Refractive indices, $n\alpha = 2.26$, $n\gamma = 2.40$.

LIMONITE. Hydrous oxide of iron, $2Fe_2O_3.3\ H_2O$; massive, compact stalactitic, botryoidal, columnar, fibrous, earthly; color yellow, brown to black. Streak yellow-brown. Submetallic to dull luster. H. 5–5.5; Sp. Gr. 3.6–4.0; Refractive index, 2.05.

SPINEL

Oxide of Aluminum and Magnesium, $MgO.Al_2O_3$.

H. 8; Sp. Gr. 3.5–4.1; Refractive index, $n = 1.723–1.75$.

Spinel in the fine red varieties commonly called 'ruby spinel' is a valuable gem mineral. Up to the present time its occurrence in the state is limited to small grains found in some of the gold-bearing

sands and gravels. Small crystals have been found in the rocks in Butte County near Oroville. *Picotite* a brown variety is found at Rocklin, Placer County, Hanks (1).

San Bernardino County. Black spinel occurs in basalt flows south of Pipe Canyon and in basalt near Quail Springs.

San Diego County. Deep green (*pleonaste*) in small octahedrons occurs at the Mack Mine, Rogers (1).

San Luis Obispo County. Ruby spinel has been observed near San Luis Obispo, Kunz (1).

Siskiyou County. Picotite occurs in the basalts of Mt. Shasta, Hanks (1).

CASSITERITE—Tin Stone

Oxide of Tin, SnO_2.

H. 6–7; Sp. Gr. 6.8–7.1; Refractive indices, $N_\alpha = 1.997$, $n_\gamma = 2.093$.

Cassiterite, wood tin or tin stone, as it is called, is rare in California. Fine material when cut and polished yields handsome lustrous gems.

It has been found at Michigan Bluff, Placer Co., and three miles above Big Bar in the Feather River, Plumas Co., Hanks (1).

Riverside County. At the Temescal tin mine, in a vein of tourmaline and quartz.

San Diego County. As a constituent in some of the gem mines.

Siskiyou County. At Sawyers Bar and on Hungary Creek.

Trinity County. Near Weaverville, Hanks (1).

CARBONATES

ANHYDROUS CARBONATES

CALCITE—Calc Spar—Limestone

Carbonate of Calcium, $CaCO_3$.

H. 3; Sp. Gr. 2.71; Refractive indices, $n_\alpha = 1.486$, $n_\gamma = E.658$.

Calcite is an exceedingly common mineral and though seldom used as a gem stone, varieties of it are important ornamental stones. Among these are marble, onyx or 'onyx marble', travertine, aragonite and limestone. The variety called 'oolite' contains black spherulitic calcite in a white matrix of the same material.

Calcite is found in practically every county, several of which are important commercial producers, Eakle (1).

Satin Spar is a fibrous crystalline variety showing when cut and polished a beautiful sheen. When cut cabochon shows a cat's-eye effect.

MAGNESITE

Carbonate of Magnesium, $MgCO_3$.

Magnesite is a very common mineral in the state being found with the serpentinized rock in veins and sometimes in deposits of considerable extent. It occurs in dense compact masses, the color is white to gray and the siliceous varieties possess considerable hardness.

As an ornamental stone magnesite possesses qualities which make it suitable for carved objects of all kinds; the harder varieties in par-

ticular are capable of receiving a glossy polish and where it is utilized for smokers' articles it has an appearance similar to meerschaum.

RHODOCHROSITE

Carbonate of manganese, $MnCO_3$.

H. 3.5–4.5 ; Sp. Gr. 3.45–3.60 ; Refractive indices, $n_\alpha = 1.597$, $n_\gamma = 1.817$.

A few specimens of a rose-red color have been found in the state. The mineral is usually found in the gold-silver regions where manganese is associated with the veins, Eakle (1).

SMITHSONITE

Carbonate of zinc, $ZnCO_3$.

H. 5 ; Sp. Gr. 4.45 ; Refractive indices, $n_\alpha = 1.618$, $n_\gamma = 1.818$.

Smithsonite in the fine green shades is often cut as a gem stone. Although like other carbonates it lacks sufficient hardness to be a durable gem stone, its soft green color is very pleasing and when worn as a pendant or brooch stone will give good service.

Found chiefly in Inyo County, at Cerro Gordo, Hanks (1), and various localities in San Bernardino County.

HYDROUS CARBONATES

MALACHITE—Green Copper

Basic carbonate of copper, $CuCO_3.Cu(OH)_2$.

H. 3.5–4 ; Sp. Gr. 4 ; Refractive indices, $n_\alpha = 1.655$, $n_\gamma = 1.909$.

Malachite is found in practically all localities where there is a trace of copper, being an alteration mineral of copper compounds. Although fine specimens are found, hard compact material suitable for cutting and polishing is scarce. As a general rule other copper minerals are associated with it—azurite, chalcocite, cuprite, chrysocolla.

A combination of several of these minerals called 'Mala-Cuprite' is composed essentially of malachite and cuprite with chalcocite and chrysocolla. This material cuts into fine and attractive gem stones. True malachite is extensively used for carvings and for ornamental purposes as well as inlay work.

AZURITE—Blue Malachite

Basic carbonate of copper, $2CuCO_3.Cu(Oh)_2$.

H. 3.5–4 ; Sp. Gr. 3.77–3.83 ; Refractive indices, n 1.739, n 1.836.

Azurite is usually found with malachite in the copper mines, though not so common. It generally occurs in aggregates of crystals but it is sometimes found compact with malachite, the two being cut together and the gem is then called 'azur-malachite.'

ANHYDROUS SILICATES

FELDSPARS

The name feldspar is given to a group of alumina silicates with potash, soda, and lime, whose members have the same general properties of hardness, cleavage, specific gravity and twinning order. They include; two potash feldspars, orthoclase and microline; a potash-soda feldspar, anorthoclase; a soda feldspar, albite; a lime feldspar, anorthite; and four soda-lime to lime-soda feldspars intermediate between albite and anorthite, namely oligoclase, andesine, labradorite and bytownite. The feldspars are the most abundant and most important of the rock-forming silicates, and the classification of an igneous rock is in general based upon the prevailing feldspar. The potash feldspars are characteristic of the acid group while the albite-anorthite feldspars belong to the basic group, the terms acid and basic meaning whether high or low in silica percentage. The albite-anorthite feldspars are commonly called the plagioclase feldspars.

ORTHOCLASE—Potash Feldspar

Silicate of potassium and aluminum, $KAlSi_3O_8$.

H. 6; Sp. Gr. 2.57; Refractive indices, $n_\alpha = 1.518$, $n_\gamma = 1.526$.

Orthoclase is an essential constituent of the acid igneous rocks, granites, syenites, quartz-porphyries, rhyolites and trachytes and is also found in other more basic rocks. The color of granites is mainly due to the orthoclase, red granite having the orthoclase colored by ferric oxide. Granites, syenites and diorites are often intersected by pegmatite veins and these veins vary greatly in width and some can be quarried for the feldspar. Orthoclase is sometimes found in transparent lemon-yellow crystals which may be cut into beautiful faceted gems.

The principal commercial deposits in California are in Monterey, Riverside, San Diego, and Tulare counties.

Adularia is a glassy variety and is sometimes found in large crystals.

Graphic Granite

Graphic Granite consisting essentially of orthoclase feldspar and quartz, derives its name from its peculiar markings, the orthoclase crystals being arranged in patterns resembling Hebrew writing.

This interesting rock is found in the pegmatites of San Diego and Riverside counties and is common at Soulsbyville in Tuolumne County. It also occurs in Mariposa County.

Graphic Granite is capable of receiving a high polish and is excellent for ornamental objects.

MICROCLINE—Potash Feldspar

Silicate of potassium and aluminum $KAlSi_3O_8$.

H. 6; Sp. Gr. 2.54–2.57; Refractive indices, $n_\alpha = 1.522$, $n_\gamma = 1.530$.

Microcline has the same composition as orthoclase but differs from it in its crystallization and twinning structure.

Amazonite, is the gem name given to the various tints of green and is extensively used for jewelry purposes the mineral being cut into all forms.

OLIGOCLASE—Soda-lime Feldspar

Silicate of sodium, calcium and aluminum, $mNaAlSi_3O_8$, with $nCaAl_2Si_2O_8$.

H. 6; Sp. Gr. 2.65–2.67; Refractive indices, $n_\alpha = 1.539$, $n_\gamma = 1.547$.

Occurs as a contituent of various igneous rocks.

Moonstone, in the gem trade called 'oriental moonstone' in order to distinguish it from the common chalcedony, is a semi-transparent to milky variety possessing white to bluish-white chatoyance.

Oligoclase is a constituent of the glaucophane rocks of Santa Clara County.

LABRADORITE—Lime-soda Feldspar

Silicate of calcium, sodium and aluminum, $CaAl_2Si_2O_8$, with $NaAlSi_3O_8$.

H. 6; Sp. Gr. 2.70–2.72; Refractive indices, $n_\alpha = 1.559$, $n_\gamma = 1.568$.

An essential constituent of most basic eruptive rocks. Sometimes it occurs in veins of large cleavable masses.

Los Angeles County. Labradorite is a constituent of the rocks on Mount Gleason; in the rocks of Yosemite Park, Mariposa County; and pebbles containing inclusions of native copper have been found in Modoc County.

Plumas County. Found in the rocks at Engels Copper mine.

Santa Barbara County. A constituent of the teschenites at Point Sal.

PYROXENE GROUP

ENSTATITE

Silicate of magnesium, $MgSiO_3$.

H. 5.5; Sp. Gr. 3.1–3.3; Refractive indices, $n_\alpha = 1.650$, $n_\gamma = 1.656$.

Enstatite is a rock-forming mineral characteristic of gabbroitic rocks and rocks that have been derived from gabbros, like much of the rocks of the Coast Range and of the Sierras which have become serpentinized.

Bronzite is a variety in which part of the magnesium has been replaced by iron. It occurs in bronze-brown reticulated masses.

HYPERSTHENE

Silicate of iron and magnesium $(Fe,Mg)SiO_3$.

H. 5–6; Sp. Gr. 3.4–3.5; Refractive indices, $n_\alpha = 1.692$, $n_\gamma = 1.705$.

Hypersthene is a constituent of basic eruptive rocks particularly gabbros and andesites.

Enstatite, bronzite and hypersthene are sometimes used for gem purposes. When properly cut, due to the fibrous structure they have a pleasing cat's-eye effect.

Cut by courtesy of Albert A. Sperisen.

Kunzite from Pala, California.

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DIOPSIDE

Silicate of calcium, iron and magnesium, $Ca(MgFe)(SiO_3)_2$.

H. 4–6; Sp. Gr. 3.2; Refractive indices, $n_\alpha = 1.67$, $n_\gamma = 1.70$.

Diopside is found in crystalline limestones as a contact mineral associated with garnet. It also occurs in schists and other types of metamorphic rocks and is sometimes found in gabbros and peridotites.

Diopside is found in several counties in the state. This grass-green mineral affords gems of considerable beauty.

Contra Costa County. Common in the schists near San Pablo.

El Dorado County. Fine dark-green crystals occur near Mud Springs and in good crystals at the Cosumnes Copper Mine.

Los Angeles County. Large light-green crystals are found near San Pedro.

Riverside County. Crystals of pale-green diopside occur in the limestone at Crestmore.

SPODUMENE

Silicate of lithium and aluminum, $LiAl(SiO_3)_2$.

H. 7; Sp. Gr. 3.13–3.20; Refractive indices, $n_\alpha = 1.660$, $n_\gamma = 1.676$.

Spodumene is found in pegmatite veins where lithia is present. Sometimes the crystals are of exceptional size.

Hiddenite is the name given to the green varieties.

Kunzite is spodumene in the shades of lilac and violet.

The discovery of lilac-colored spodumene in the mineral deposits of southern California in the early part of the present century was of unusual interest and notable importance, being an entirely new mineral species, the first time lilac-colored spodumene was found. Although the mineral spodumene was known to mineralogists prior to this discovery it had never before been found in lilac or violet colors and with the exception of a few occurrences the transparent gem crystals were of small size.

When they were first found in San Diego County, being associated with tourmaline, they were at first thought to be a variety of that mineral. Specimens found by Frederick M. Sickler, were sent to George F. Kunz in Dec. 1902 for determination, who upon examination recognized the mineral as spodumene. In his honor this beautiful lilac gem mineral was named 'Kunzite' the name being proposed by Prof. Chas. Baskerville of the University of North Carolina, Baskerville (1).

Besides their unusual color and transparency many of the crystals found were of extraordinary size, some of the largest were recorded as follows:

No. 1.	528.7 gm	17 x 11 x 1 centimeters
No. 2.	528.7 gm	22 x 8 x 1.5 centimeters
No. 3.	297.0 gm	19 x 5.5 x 1.5 centimeters
No. 4.	258.6 gm	23 x 4 x 2 centimeters
No. 5.	340.5 gm	13 x 6 x 2.52 centimeters
No. 6.	239.5 gm	18 x 4 x 2 centimeters
No. 7.	1000.0 gm	18 x 8 x 3 centimeters

Soon after the discovery the locality was visited and examined by Dr. Waldemar T. Schaller then of the geological department of the University of California, who reported as follows, (1):

"The formation in which these fine crystals are found at the Pala locality consists of a pegmatite dike, dipping westerly at a low angle perhaps 20 degrees. It is more or less broken, and as a whole seems to form the surface of much of the slope of the hill on which it occurs. The dike is rather broad but irregular in its present shape, and has a thickness probably of not more than thirty feet. So far as the mining developments have shown, only a small portion of the dike is rich in lithia minerals.

"Ordinarily the dike is a coarse muscovite-granite, the orthoclase and quartz predominating containing many rounded prisms of black tourmaline with broken ends. Lepidolite, occasionally seems to replace the muscovite and when it does, red, blue and green tourmaline replace the black variety.

"It is with these gem-tourmalines that the spodumene occurs. While the tourmaline and lepidolite are frequently inclosed in the quartz and feldspar, no such inclusions of spodumene have been found. The latter mineral always occurs associated with the other minerals, but never penetrating them or penetrated by them. It occurs in pockets, and these facts seem to indicate that the formation of the spodumene is later and not coincident in time of formation with the tourmalines and with the dike. The dike cuts across the large intrusion of dark rock occurring at Pala and briefly mentioned by Dr. H. W. Fairbanks, (1).

"This large body of dark rock several miles across is surrounded on all sides by granite. The dark rock forming the foot-wall of the dike in which the spodumene occurs is a diorite, consisting of hornblende, a plagioclase and (surbordinate) orthoclase with accessory magnetite and apatite."

The original discovery made by Frederick M. Sickler was a product of the White Queen mine on the ridge east of the Pala Chief now known as Heriart Mountain. In 1902 and 1903 considerable exploration work was done which resulted in the discovery of the notable tourmaline and kunzite mine on Pala Chief Mountain.

Many outcrops and openings showed lepidolite and several showed kunzite at various points on the ends and on both sides of the ridge. Eleven claims in all were recorded and more or less developed. A peculiar reddish clayey mineral matter that occupies the cavities in which nearly all of the gem minerals are found is a form of halloysite.

Kunzite has also been found in Riverside County at the Fano mine near Coahuila, which was located in 1902 by Bert Simmons, and for some time bore his name. It occurs here both pink and colorless chiefly and is also found in yellow, green, and blue.

The colored varieties of spodumene show marked pleochroism, some specimens when viewed transversely may be gray or nearly colorless and when viewed longitudinally they present deep tones of lilac or amethyst, etc. All of the crystals show deeply etched faces.

Kunzite becomes strongly luminescent on exposure to a static charge of electricity. When a cut gem is suspended between the two poles it becomes an intense orange-pink color glowing with wonderful brilliance. On exposure to the rays of ultra-violet light the crystals phosphoresce for some moments.

The response to the Roentgen or X-Rays is most remarkable and many interesting experiments were conducted by Kunz, (1).

Many fine gems have been cut from this mineral. Numerous specimens of crystals and cut gems are in the Tiffany-Morgan collection in the American Museum of Natural History in New York.

PECTOLITE

Basic silicate of calcium and sodium, $HNaCa_2(SiO_3)_2$.

H. 5; Sp. Gr. 2.68–2.78; Refractive indices, $n_\alpha = 1.595$, $n_\gamma = 1.634$.

White pectolite occurs in veins and patches in altered basic dikes and flows and in serpentinized rocks.

As early as 1887 large masses of pectolite were found in the serpentine on Elder Creek, Tehama Co., Kunz (1). Here it occurs in a vein from two to three inches in thickness and in dense and compact masses. The fractured surfaces of the broken material exhibit characteristic silky luster. When cut and polished this mineral exhibits a beautiful sheen from the fibrous crystalline structure. Massive white fibrous pectolite also occurs in the serpentines at Fort Point in San Francisco County.

RHODONITE

Silicate of manganese, $MnSiO_4$.

H. 5.5–6.5 ; Sp. Gr. 3.4–3.68 ; Refractive indices, $n_\alpha = 1.726$, $n_\gamma = 1.737$.

Rhodonite, the rose-red manganese silicate is extensively used for gem purposes and ornamental objects of all types, dishes and trays, etc.

It is often present in copper and silver mines where oxide of manganese is abundant and it is usually associated with pyrolusite or psilomelane. It is generally developed as a contact mineral in veins.

Rhodonite of good gem quality occurs in the following counties:

Alameda County. At the Corral Hollow manganese deposit.

Butte County. Found on the North Fork of Feather River.

Madera County. Found near Coarse Gold.

Placer County. At Forest Hill.

Plumas County. Good red rhodonite is found in many of the valleys and canyons and in the Genessee Meadow.

Siskiyou County. Fine specimens of rhodonite occur at Sawyer's Bar. Rhodonite partly altered to the black manganese oxides occurs near Gazelle and on the South Fork of Salmon River. Specimens have come from Empire Creek, also Dutch Creek and Gottville. Massive material of good red color with black oxides occurs on Indian Creek near Happy Camp.

Tulare County. Some good gem rhodonite occurs about three miles north of Lemon Cove.

Tuolumne County. Found on Rose Creek near Columbia, also in veins two miles north of Sonora.

BERYL

Silicate of beryllium and aluminum, $Be_3Al_2Si_6O_{18}$.

H. 7.5–8 ; Sp. Gr. 2.63–2.80 ; Refractive indices, $n_\alpha 1.564, = n_\gamma = 1.568$.

The mineral species beryl, includes several varieties varying greatly in color and value and known by different names:

Emerald is the deep to grass-green type.

Aquamarine is sea-green to sky-blue.

Golden beryl, yellow.

Morganite is the deep pink to rose-red.

Other names have been applied to varying color varieties, but generally these are called beryl. Beryl occurs in several parts of southern

California associated with the other gem minerals, and every color variety with the exception of emerald has been found there. This is one of the most important gem minerals, as at the present time fine quality emeralds are the most valuable of gem stones. Aquamarines are fashionable and in great demand.

The never-ending quest for new alloys has brought the metal beryllium into prominence. This metal, lighter than aluminum, with the strength of steel, and possessing great hardness is being rapidly developed for commercial use.

The chief localities are in Riverside County, and in particular San Diego County, at Pala, Mesa Grande, and Jacumba.

LAZURITE—Lapis-Lazuli

Silicate of sodium and aluminum with sodium sulphide, $Na_4(NaS_3Al)Al_2(SiO_4)_3$.

H. 5–5.5; Sp. Gr. 2.38–2.45; Refractive index, $n = 1.50$.

The blue ornamental mineral, lapis-lazuli, is rare and is only known in one locality in California. Fine quality specimens are highly prized, and by some authorities it is declared to be the only real blue gem-stone known.

Lapis-lazuli has been prized from the earliest times. It was the finest ornamental stone used in ancient Egypt, Assyria and Babylonia and the mines are still being worked today after a period of some 6,000 years.

Lapis-lazuli was the mineral used for making the beautiful blue ultramarine of the Egyptians. It is interesting to note that a number of artists today, have provided themselves with pigment made in a similar manner.

San Bernardino County. Small boulders of limestone containing lapis-lazuli with pyrite occur in the bed of San Antonio Creek, near Uplands. The boulders come from an old prospect which was thought to be a silver deposit. It occurs on the north slope of the south fork of Cascade Canyon, one and a half miles east of the 'Hogback', in San Antonio Canyon, twelve miles from Upland. The occurrence has been described as lapis-lazuli by Surr (1). (However, see Bulletin 113, p. 229).

GARNET

Silicate of Ca, Mg, Al, Fe, Cr, Mn, forming several varieties.

H. 6.5–7.5; Sp. Gr. 3.15–4.3.

Garnet is one of the common minerals of the state and a number of varieties are known to occur. It is generally a product of metamorphism and is common in metamorphic rocks such as gneiss, schist, quartzite and crystalline limestone. As a contact mineral formed by the intrusion of igneous rock into limestone and other rock, it is often found in fine large crystals. It is a common constituent of beach sands and of the concentrates of mining districts. There are several varieties based on composition.

Type	*Composition*		*Sp. Gr.*	*Refractive Index* $n =$
Grossularite	Lime-alumina garnet (essonite, hyacinth, cinnamon stone)	$CaAl_2(SiO_4)_3$	3.4–3.7	1.735–1.763
Pyrope	Magnesia-alumina garnet	$Mg_3Al_2(SiO_4)_3$	3.7	1.705–1.742
Almandite	Iron-alumina garnet	$Fe_3Al_2(SiO_4)_3$	3.9–4.2	1.778–1.830
Andradite	Lime-iron garnet (melanite, demantoid, topazolite)	$Ca_3Fe_2(SiO_4)_3$	3.75	1.865–1.895
Spessartite	Manganese-alumina garnet	$Mn_3Al_2(SiO_4)_3$	4–4.3	1.800–1.811
Uvarovite	Calcium-chrome garnet	$Ca_3Cr_2(SiO_4)_3$	3.4–3.5	1.838

Garnet is one of the most important gem minerals being extensively used in all types and classes of jewelry. Cabochon cuts in almandite or pyrope are called 'carbuncles'. Color varies greatly among the various types and even in the one species, thus grossularite when clear and light green is called 'gooseberry' stone, when translucent to opaque, 'African jade' and the brown variety, essonite, is the 'hyacinth' of the jeweler.

Andradite varies considerably also; melanite is black; demantoid, the beautiful yellow-green garnet, is the 'olivine' of the jeweler, and 'topazolite' is brown.

The majority of the garnets used are in the two classes: Almandite and Pyrope. While the garnets are extensively used as gems, they have many commercial uses, the most important of which is its utilization in the manufacture of garnet paper and cloth for the wood-working industry, approximately 8,000 tons of which is used annually.

With its high degree of luster (sub-adamantine) garnets make excellent gems. One variety of andradite, demantoid, has unusually high dispersion .057 and closely approaches the diamond in fire. When properly cut these stones exhibit a remarkable play of color.

In California garnets are extensively distributed throughout the state and are found in nearly all counties; the most important of which follow:

Calaveras County. Good crystals of andradite in schist at the Shenandoah mine. Andradite is found with idocrase and epidote at Garnet Hill above the confluence of Moore Creek and Mokelumne River.

El Dorado County. Large crystals of grossularite have been found at the old Cosumnes copper mine. Good crystals nine miles southeast of Placerville. Common near Georgetown.

Fresno County. Occurs at Grub Gulch and Fort Miller. The limestone near Trimmer contains much garnet. Brown garnet with green tourmaline on Spanish Peak in a ledge of white quartz. In calcite at San Ramon a white garnet occurs with the green californite on the south side of Watt Valley.

Inyo County. Fine large crystals of glossularite occur associated with white massive datolite and greenish-brown vesuvianite at the San Carlos mine. Andradite with epidote and scheelite in Deep Canyon.

Mariposa County. Andradite crystals are found on Mount Hoffman.

Monterey County. An unusual form of garnet being a combination of uvarovite and chromite is found in the county.

Nevada County. Fine green crystals of uvarovite are found at the Red Ledge mine associated with rhodochrome and kammererite.

Placer County. Fine uvarovite crystals have been found on chromite seven miles southeast of Newcastle at Farmer Swanton mine.

Riverside County. Occurs massive at the Santa Ana district. Essonite is found at Hemet. Abundance of grossularite and some andradite garnet occurs in the crystalline limestone at Crestmore. Essonite in fine crystals are found at Coahuila and near Mecca.

San Diego County. This is the most important garnet producing county and several types are found in the various gem mines. The finest essonite crystals were obtained from Ramona, associated with other gem minerals, beryl, tourmaline, white topaz, occasionally in perfect dodecahedrons and trapzohedrons, of rich honey-yellow to orange-red color. Essonite of very fine quality has been found in the Hercules, Lookout, Surprise and Prospect mines from some of which fine stones weighing from six to eight carats have been cut.

Sonoma County. Large masses of garnet occur near Petaluma. Almandite garnets occur abundantly in a chlorite schist on the Cox ranch three miles west of Healdsburg, with glaucophane and actinolite in schists at Camp Meeker and near Healdsburg. Almandite garnets occur in chlorite schist west of Healdsburg.

Trinity County. Uvarovite in emerald-green crystals occur on chromite near Carrville. Andradite occurs at Peanut. Colorless grossularite occurs associated with epidote, titanite and zircon in a soda granite-porphyry in the Iron Mountain district.

Tulare County. Several varieties occur at different points: essonite at Three Rivers, pyrope on Rattlesnake Creek, and topazolite near the chrysoprase locality 12 miles northeast of Visalia. Almandite is abundant between the North and Middle forks of Tule River. Massive white grossularite is found near Selma.

OLIVINE—Chrysolite-Peridot

Silicate of magnesia and iron, $(Mg,Fe)_2SiO_4$.

H. 6.5–7; Sp. Gr. 3.27–3.37; Refractive indices, $n_\alpha = 1.662$, $n_\gamma = 1.699$.

Olivine is a rock-forming mineral which is practically limited to basic igneous rocks such as basalt, andesite, gabbro and peridotite. When the mineral is found clear and limpid it constitutes a gem mineral of importance and considerable beauty.

Chrysolite is the name applied to the lighter varieties, in color ranging from lemon-yellow to yellow-green.

Peridot is applied to all of the darker olive-green shades.

Peridot was most highly prized by the ancient Greeks and Romans and in certain periods was in high favor as a seal stone.

Most of the olivine in the state is found in the form of grains as a sand constituent.

As a constituent of basalt it is found in the following counties:

San Bernardino County. Large bombs of granular olivine occur in the rock of the Morongo district. Common also in the lavas along the State Highway near Amboy.

Butte County. As a constituent of diabase at Mooreville Ridge.

Modoc County. Found in basalt near Cedarville.

WERNERITE—Scapolite

H. 5–6; Sp. Gr. 2.66–2.73; Refractive indices, $n_\alpha = 1.545$, $n_\gamma = 1.567$.

Wernerite, when found clear and transparent may be cut into gem stones of considerable beauty.

Scapolite is the name given a group of rock-forming silicates consisting of isomorphous mixtures of $Ca_4Al_6Si_6O_{25}$ with $Na_4Si_9O_{24}Cl$. Wernerite is the most common member of the group. The scapolites are in general formed by contact metamorphism.

Scapolite occurs in Nevada County at Nevada City and Grass Valley.

Riverside County. As an associate mineral at Crestmore and in small dikes on Eagle Mountain.

IDOCRASE—Vesuvianite

Basic silicate of calcium and aluminum, $H_4Ca_{12}(Al,Fe)_6Si_{10}O_{43}$.

H. 6–6.5; Sp. Gr. 3.35–3.45; Refractive indices, $n_\alpha = 1.722$, $n_\gamma = 1.723$.

Vesuvianite is a characteristic mineral formed in limestone near the contact with intrusive rocks. Small prismatic crystals suitable for cutting have been found near Georgetown, El Dorado County, on the property of W. L. Stifle. Some of the crystals found were of a fine grass-green color and were mistaken for emeralds.

A compact variety called 'californite' (california jade), was first found on the south fork of Indian Creek about 12 miles from Happy Camp and ninety miles from Yreka in Siskiyou County.

Californite varies in color from white and greenish-yellow to dark green. The outcrop at Happy Camp extends some 200 feet along the hillside and large boulders have fallen to the creek below. The country rock is serpentine. It was at first supposed to be jade and has been called California Jade. Analysis however proves it to be vesuvianite.

This mineral is hard and compact and is extremely tough and difficult to break with a hammer. It is capable of receiving and retaining a high polish and the clearer pieces make fine gems. A considerable quantity of this mineral has been sent to China where it is carved into ornamental objects of all kinds.

Butte County. Californite in translucent to opaque white and beautiful lemon-green color is found at the Jade Mountain Mine near Pulga on the North Fork of Feather River. It occurs in seams and as veins in serpentine.

El Dorado County. Brown crystals of vesuvianite at the Siegel Lode.

Fresno County. Californite occurs on the east side of Watts Valley about 32 miles east of Fresno.

Inyo County. Brownish-green crystals were associated with garnet and massive white datolite at the San Carlos Mine.

Riverside County. Green and brown vesuvianite are common in the crystalline limestones at Crestmore.

San Diego County. Brown vesuvianite is found about ten miles east of Jacumba.

Tulare County. Californite is found in the chrysoprase locality east of Porterville also found about 35 miles east of Selma.

ZIRCON

Silicate of zirconium, $ZrSiO_4$.

H. 7.5; Sp. Gr. 4.68–4.7; Refractive indices, $n_\alpha = 1.931$, $n_\gamma = 1.993$.

Zircon is invariably an associated mineral in acid eruptive rocks such as granites and syenites. The concentrates from the gold washings and the black sands usually carry some zircon grains and crystals.

There are no records showing zircons have been found in California in sizes large enough for gem cutting.

TOPAZ

Silicate of aluminum and flourine, $Al(O,F_2)AlSiO_4$.

H. 8; Sp. Gr. 3.4–3.65; Refractive indices, $n_\alpha = 1.619$, $n_\gamma = 1.627$.

Topaz occurs in veins in metamorphic and eruptive rocks, where fluorine has accompanied the formation of the vein. It is usually associated with tourmaline and other minerals whose formation has been due to the action of gases on the constituents of the rock.

Topaz is a durable and important gem mineral. Its hardness, brilliance and fine color all contribute to make a gem of great beauty.

Excellent topaz crystals, often of considerable size, have been found in San Diego County, near Ramona. Here the mineral is found in a pegmatite ledge. The crystals are not uniformly distributed throughout the rock but occur in zones or pockets.

The principal producers have been the mines known as the Surprise and The Little Three. These mines adjacent to each other are about four and a half miles northeast of Ramona. Associated with them are dark-green tourmaline crystals, albite and orthoclase feldspar. The topaz crystals found near the surface were colorless but at greater depth were of a sky-blue to deep aquamarine-blue. Over fifty pounds of them were taken from a cut 20 ft. long and 8 ft. wide. Fine crystals, light-green in color occur in the Aguanga Mountains.

ANDALUSITE—Chiastolite

Silicate of aluminum, Al_2SiO_3.

H. 7.5; Sp. Gr. 3.16–3.20; Refractive indices, $n_\alpha = 1.632$, $n = 1.643$.

Andalusite occurs as a constituent of gneisses and schists and is usually associated with kyanite, sillimanite and staurolite.

Chiastolite is a variety found in carbonaceous schists, in knotty and long prismatic crystals having black inclusions of carbon arranged axially and thus forming black crosses seen in transverse sections.

Mariposa County. Choice crystals of chiastolite are found in schist along Chowchilla River near the old road to Fort Miller.

KYANITE—Disthene

Silicate of aluminum, Al_2SiO_3.

H. 5–7; Sp. Gr. 3.56–3.67; Refractive indices, $n_\alpha = 1.712$, $n_\gamma = 1.728$.

Kyanite is a common metamorphic mineral found in schists and gneisses with andalusite, sillimanite and dumortierite.

When of a fine uniform blue color they are cut into gems of distinction.

ZOISITE

Basic silicate of calcium and aluminum, $HCa_2Al_3Si_3O_{13}$.

H. 6–6.5; Sp. Gr. 3.25–3.37; Refractive indices, $n_\alpha = 1.700$, $n_\gamma = 1.706$.

Zoisite belongs to the metamorphic class of minerals and is often developed by the metamorphism of gabbros and diorites.

Saussurite is a mixture of zoisite, calcite and plagioclase feldspar.

Thulite is a rose-red variety which makes attractive cut stones.

Found in Lake County at Sulphur Bank; Plumas County in the Diadem Lode, Meadow Valley; also in Riverside, Santa Clara and Shasta counties, Eakle (1).

EPIDOTE

Basic silicate of calcium, aluminum and iron, $HC_2(Al,Fe)_3Si_3O_{13}$.

H. 6–7; Sp. Gr. 3.25–3.5; Refractive indices, $n_\alpha = 1.729$, $n_\gamma = 1.768$.

Epidote is a common mineral in the state, especially as an alteration mineral in crystalline rocks. It is often found in aggregates of large crystals and columnar masses in veins with quartz and feldspar. The colors range from pistachio to dark green, dark brown, yellow.

Most of the epidote found is opaque or so badly fractured that it is impossible to cut good stones, however, clear transparent crystals are found at the McFall mine seven and one-half miles southeast of Ramona in San Diego County.

AXINITE

Borosilicate of aluminum and calcium with iron and manganese.

$H(Ca,Mn,Fe)_3BAl_2(SiO_4)_4$.

H. 6.5–7; Sp. Gr. 3.27; Refractive indices, $n_\alpha = 1.678$, $n_\gamma = 1.688$.

Crystals of axinite are sometimes developed in the veins and along the contact of intrusive rocks but the mineral is rare in its occurrence.

Fine crystals of exceptional beauty occur in the southern part of the State. A large crystal of axinite was found in the city quarry at Riverside, which measured 9 x 12 x $1\frac{1}{2}$ centimeters. The axinite of this quarry is a violet brown, Rogers (2).

Violet axinite occurs associated with cinnamon garnet in the pegmatite at Crestmore. Crystals of violet-colored axinite are also found in the Box Springs Mountains.

San Diego County. Smoky-pink crystals, a beautiful "ashes of roses" tone are found in an altered granite in Moosa Canyon, about 18 miles south of Pala near Bonsall, associated with quartz, epidote, and laumontite.

PREHNITE

Acid silicate of calcium and aluminum, $H_2Ca_2Al_2Si_3O_{12}$.

H. 6–6.5; Sp. Gr. 2.8–2.95; Refractive indices, $n_\alpha = 1.616$, $n_\gamma = 1.649$.

Green drusy coatings and veins of prehnite are sometimes present in altered diabase and lavas. Its soft green color makes it an attractive

gem stone or ornamental stone. Riverside County, a constituent of the pegmatite veins at Crestmore.

TOURMALINE

Borosilicate of aluminum with various bases.

H. 7–7.5; Sp. Gr. 2.98–3; Refractive indices, $n_{\alpha}=1.631$, $n_{\gamma}=1.653$.

Black tourmaline is a common mineral in the state and large areas of tourmaline granite exist in the Sierra Nevada. The common black tourmaline is characteristic of granites and quartz veins in granites. Brown tourmaline is found in crystalline limestone near the contact with intrusive igneous rocks. The transparent green and red shades occur in pegmatite veins which carry lithia and they are classed as lithia-tourmalines. The red tourmaline is known as *rubellite,* the blue as *indicolite* and the colorless as *achroite.*

The first discovery of colored gem tourmaline in the state goes back to 1872 when Henry Hamilton in June of that year obtained this mineral in Riverside County, the specimen having come from the southeast slope of Thomas Mountain. Some mining was done at this point and fine gems recovered. By 1893 several mines were in operation, the San Jacinto, and the Columbian being near Riverside. The vein varies from pure feldspar to feldspar with quartz and in others all mica, the vein being from 40 ft. to 50 ft. wide. The tourmalines varied from small size to crystals over four inches in diameter. The larger crystals found had a green exterior and red or pink inside. Some of the crystals contained green, red, pink, black and other colors.

Between 1890 and 1894 several other deposits of importance were found at Pala, in San Diego County. In Pala a little west of Smith's Mountain in the Peninsula range a ledge of lepidolite containing rubellite has been found which was traced for over half a mile. The rubellite was in clusters and radiations, several inches in diameter, also occasionally as single crystals and the specimens of deep-pink tourmaline in the pale-lilac mica made beautiful specimens. About eighteen tons were shipped during 1892.

The next important discovery was made in 1898 at the Mesa Grande locality some 20 miles southeast of Pala. This deposit was known to the Indians for many years, as tourmaline crystals were found in the burial grounds. The ledge in which they occur is exposed by erosion on the side of the mountain and the crystals were exposed.

The great Pala Chief mine which has given its name to the middle one of the three mountains at Pala, has produced magnificent tourmalines as well as the largest and finest gem spodumene (kunzite) in the world.

Subsequently through prospecting, other mines were opened in Riverside County at and around Ramona. One of these mines, called the San Jacinto gem mine, produced over a bushel of red and green crystals during the first year of operation. One of these measured eight inches in length and several inches in diameter. This was purchased by Harvard University, with other crystals several inches long and two inches in diameter. Other fine crystals were sent to the American Museum of Natural History, New York.

The Mesa Grande locality is remarkable for the great size and perfection of the tourmaline crystals, many of them being almost faultless, and doubly terminated ones being the rule rather than the exception. Bicolored crystals are quite common and often these are cut to show the two colors. Some of the crystals have circular tubelike hollows and when cut into cabochon forms, exhibit Cat's Eye effect and are called 'tourmaline cat's eye.'

This locality has been worked more thoroughly and has been more productive than any other locality in the United States. The mineralogical specimens alone were valued at $30,000 and up to 1905 the total gem value reached $200,000.

At the Pala Chief mine tourmalines a foot long and three inches in diameter were found. Many of these crystals were of a rich rubellite center with a blue coating of indicolite on the exterior.

Tourmaline is prized the world over as a gem. Its hardness, and great variety of bright colors make it a very attractive stone.

DUMORTIERITE

Basic silicate of aluminum with boron, $HAl_8BSi_3O_{20}$.

H. 7; Sp. Gr. 3.22–3.43; Refractive indices, $n_\alpha = 1.678$, $n_\gamma = 1.689$.

Dumortierite is a metamorphic mineral found in certain gneisses and schists; rare in its occurrence.

Dumortierite is somewhat difficult to polish particularly in the darker shades but attractive stones and ornamental objects may be cut from it.

Boulders of dark-blue dumortierite have been found in Imperial County twenty-five miles from Ogilby; also in Riverside County on the plains of Big Four mines, Pinacate district.

San Diego County. A violet-red variety of considerable beauty when polished, occurs near Dehesa, Schaller (2).

Tuolumne County. Boulders have been found in various parts.

HYDROUS SILICATES

MARIPOSITE

H. 2.5–3; Sp. Gr. 2.78–2.81; Refractive indices, $n_\alpha = 1.60$, $n_\gamma = 1.63$.

Mariposite is essentially a muscovite with its characteristic green color due to the presence of chromic oxide. It is characteristic of the gold belt of the Sierra Nevada.

It is common in the Mother Lode schists of Mariposa County whence it derives its name; and common also in Tuolumne County.

Mariposite in the finer grades, massive, is an excellent ornamental stone.

THOMSONITE

Hydrous silicate of aluminium, sodium and calcium, $(Na_2Ca)Al_2Si_2O_8.2\frac{1}{2}H_2O$.

H. 5–5.5; Sp. Gr. 2.3–2.4; Refractive indices, $n_\alpha = 1.497$, $n_\gamma = 1.525$.

Thomsonite is found in cavities of vesicular lava with other zeolites.

When there is contrasting color in the mineral, beautiful gem stones may be cut from it, the fibrous nature and concentric rings and bands forming a pattern of unusual interest.

Plumas County. Thomsonite is one of the zeolites occurring in the Engels copper mine.

SERPENTINE

Hydrous silicate of magnesium, $H_4Mg_3Si_2O_9$.

H. 2.5–4; Sp. Gr. 2.5–2.65; Refractive indices, $n_\alpha = 1.490$, $n_\gamma = 1.511$.

Serpentine is one of the commonest minerals and also rocks in the state. It is found in every county. It is a common alteration product of basic igneous rocks rich in magnesium silicates and it has all been formed by alteration and metamorphism of such rocks. Serpentine as a massive metamorphic rock, consists essentially of the mineral antigorite. Chrysotile, another form of serpentine is distinguished from antigorite by its fibrous structure and in differing optical properties.

Serpentine is used as an ornamental stone. Large quantities of it are carved in the Orient and often sold under different forms of 'jade' names.

TALC—Steatite—Soapstone

Hydrous silicate of magnesium, $H_2Mg_3Si_4O_{12}$.

H. 1–1.5; Sp. Gr. 2.7–2.8; Refractive indices, n_α 1.539, $n_\gamma = 1.589$.

Talc is a common mineral in the metamorphic areas of the state forming talc schists and talc gouge in mines. It is often associated with serpentine and actinolite.

Hard compact varieties are extensively used at the present time for ornamental objects.

CHRYSOCOLLA

Hydrous silicate of copper, $CuSiO_3 2H_2O$.

H. 2–4; Sp. Gr. 2–2.24; Refractive indices, $n_\alpha = 1.46$, $n_\gamma = 1.57$.

Small amounts of chrysocolla occur in most of the copper districts of the state where it is always found as an oxidation product of copper minerals. No deposits in quantity of the silicate have been found.

Inyo County. It occurs in numerous deposits in the various copper mines, being associated with azurite, cuprite, malachite and melaconite. The gem stone known as 'Mala-cuprite' contains a small percentage of chrysocolla. This mixture of copper minerals is very attractive and yields excellent gem stones, when cut.

CHLOROPAL

Hydrous silicate of iron, $H_6Fe_2Si_3O_{12}.2H_2O$.

H. 2.5–4.5; Sp. Gr. 1.72–2.01; Refractive indices, $n_\alpha = 1.625$, $n_\gamma = 1.655$.

Chloropal is a green, opal-like mineral of rare occurrence.

Nontronite is a yellowish variety.

This mineral is sometimes used as a gem, having unusual color and markings. Found in El Dorado, Kern, Mariposa, and Placer counties.

TITANO-SILICATES

TITANITE—Sphene

Titano-silicate of calcium, $CaTiSiO_5$.

H. 5–5.5; Sp. Gr. 3.4–3.56; Refractive indices, $n_\alpha = 1.900$, $n_\gamma = 2.034$.

Titanite is a common accessory mineral in the granites and gneisses and schists in the state. It is invariably found in microscopic size and large crystals are rare.

When found in sizes sufficiently large to be cut, titanite is a remarkable gem. Exceeding the diamond in dispersion, when properly cut, it is a gem of great beauty.

BENITOITE

Titano-silicate of barium, $BaTiSi_3O_9$.

H. 6.5; Sp. Gr. 3.64–3.65; Refractive indices, $n_\alpha = 1.757$, $n_\gamma = 1.804$.

Beautiful violet-blue, sapphire-blue and colorless crystals were found in San Benito County in 1907. These were at first thought to be sapphires; but they were subsequently determined to be a new mineral and named Benitoite, Louderback (1, 2). Of unusual interest is the

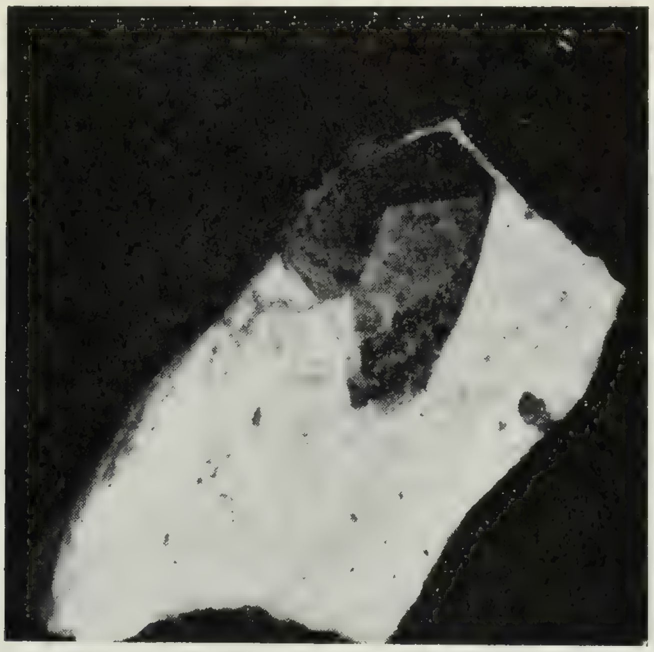

Photo by Walter W. Bradley

FIG. 2. Benitoite Crystal in Natrolite Matrix. Two-thirds natural size.

fact that this mineral was not only new but that it is the lone representative of the ditrigonal bipyramidal class of the hexagonal system. Prior to its discovery this class was projected by mathematics in accordance with the laws of symmetry.

The benitoite crystals occur in narrow veins of natrolite in serpentine near the headwaters of San Benito River; associated with it are neptunite, chalcocite, chrysocolla, actinolite, crossite, albite, aegyrite, calcite, aragonite, Joaquinite, and psilomelane.

The strong pleochroism of benitoite, requires placing the front of the cut stone parallel to the vertical axis of the crystal. A number of fine large stones are known. The largest weighing 7.65 carats, for a

Photo by Walter W. Bradley

FIG. 3. Crystals of Benitoite and Neptunite in Natrolite Matrix.

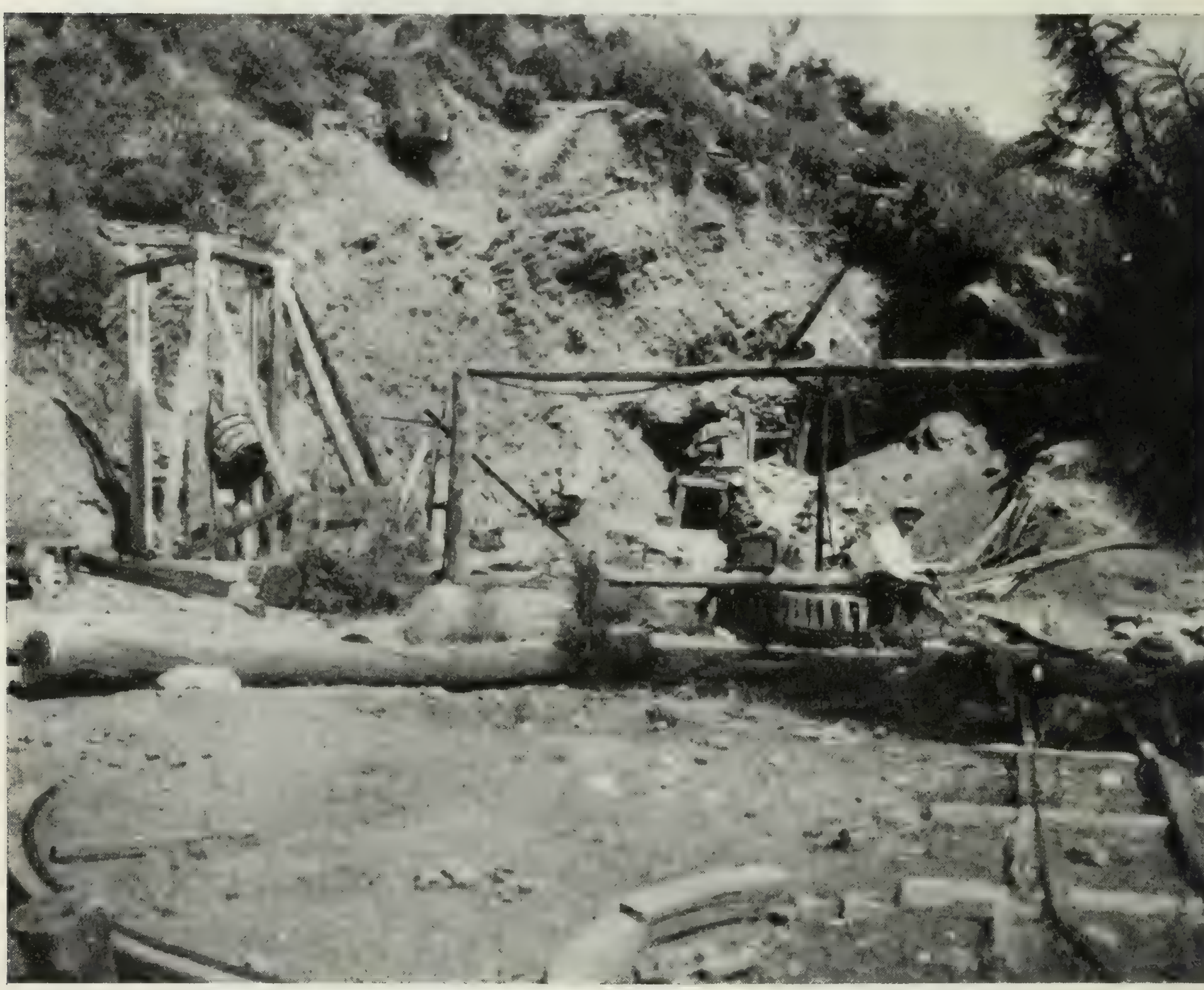

Photo by Walter W. Bradley, 1914

FIG. 4. Dallas Benitoite Mine, San Benito County.

long time the possession of a San Francisco jeweler, is now in the Smithsonian Institution, Washington, D. C. Production of benitoite has been limited to the Dallas mine, covered by two patented claims.

PHOSPHATES

APATITE

Phosphate of calcium with chlorine or flourine,
$(CaCl)Ca_4(PO_4)_3$ or $(CaF)Ca_4(PO_4)_3$.

H. 5; Sp. Gr. 3.17–3.23; Refractive indices, $n_\alpha = 1.631$, $n_\gamma = 1.634$.

Apatite has been observed as small crystals in many of the rocks of the state but no deposits of the mineral are known. A small percentage of calcium phosphate is found in many of the limestones of the state.

When transparent and clear apatite is sometimes used for gem purposes.

LAZULITE

Basic phosphate of aluminum, iron and magnesium $(Fe,Mg)Al_2(OH)_2P_2O_8$.

H. 5–6; Sp. Gr. 3.05; Refractive indices, $n_\alpha = 1.603$, $n_\gamma = 1.639$.

Lazulite is a rare phosphate, azure-blue in color, found in quartzites and metamorphic rocks.

Inyo County. Lazulite occurs in a white quartz vein in schist in Breyfogle Canyon, Death Valley.

Mono County. In a white quartzite associated with rutile near Mono Lake. Found in a quartz vein in Green Creek Canyon, near Bodie. Lazulite occurs with andalusite and pyrophyllite at the mine of Champion Sillimanite, Inc., on the western slope of the White Mountains, east of Mocalno.

TURQUOISE

Hydrous phosphate of aluminum, $AlPo_4Al(OH)_3.H_2O$.

H. 5.5–6; Sp. Gr. 2.6–2.83; Refractive indices, $n_\alpha = 1.61$, $n_\gamma = 1.65$.

Turquoise is a gem mineral of importance and has been used for such purposes for thousands of years. In some parts of the world, it is a medium of exchange.

A most notable deposit of turquoise was found in San Bernardino County, which is of historical interest, Kunz (1).

[1] "In the extreme northeastern part of this county there have been discovered old and abandoned mines of turquoise covering an area of many square miles. Associated with these mines were found the relics of an early race; and it is supposed that this is the original source of much of the turquoise found in the hands of the Indians of the southwestern United States and Mexico. The turquoise occurs in small veins and also in kidney-shaped masses about the size of a bean. Much of it is of good quality.

"The first published announcement of turquoise discoveries in this region was made through the writer in 1897, in his report to the U. S. Geological Survey.[2] The locality was given as near Manvel. Mr. T. C. Bassett had observed in this neighborhood a small hillock where the float rock was seamed and stained with blue. On digging down a few feet, he found a vein of turquoise—a white talcose material inclosing nodules and small masses of the mineral, which at a depth of 20 feet showed fine gem color. Two aboriginal stone hammers were met with, as usual at

[1] Kunz, G. F., Gems, jewelers' materials and ornamental stones of California: Bull. 37, Cal. State Min. Bur., pp. 107–110, 1905.

[2] Min. Res. U. S., 1897, p. 504.

all the turquoise localities in the southwest, and from this circumstance the location was named the Stone Hammer mine.

"The State Mining Bureau reported at about the same time that turquoise had been found in the desert region between Death Valley and Goff's Mining District, nearer the former, and that good samples were in the museum of the Bureau.

"In the spring of 1898, many reports of extensive discoveries were announced, and much attention was given by the press to the accounts of the region, both for the turquoise itself, and for the remarkable archaeological remains associated with the ancient workings. The district was seen to cover quite a large area in northeastern San Bernardino County, near the Arizona and Nevada lines.

"On the reports of prospectors reaching San Francisco as to a great group of ancient turquoise mines with cave dwellings, stone implements, and rocks covered with inscriptions, an exploring party was organized by the San Francisco 'Call,' and Mr. Gustav Eisen, of the California Academy of Sciences, became attached to it as archaeological expert.[3] The party set out early in March, 1898, going first to Blake Station on the Santa Fe Railroad, thence north to Manvel, and onward some sixty miles, across the Ivanpah Sink, and up into the mountains to an altitude of over 6000 feet, through an exceedingly rugged country, to reach the region reported. The turquoise district, as described by Mr. Eisen and others of the party, occupies an area of 30 or 40 miles in extent, but the best mines are in a smaller section, about 15 miles long by 3 or 4 in width. The region is conspicuously volcanic in aspect, being largely covered with outflows of trap or basaltic rock reaching outward from a central group of extinct craters. These flows extend for many miles in all directions, and appear as long, low ridges, separated by valleys and cañons of the wildest character. Among these basaltic rocks and in the valleys are found smaller areas of low, rounded hills of decomposed sandstones and porphyries, traversed at times by ledges of harder crystalline rocks, quartzites, and schists. In the cañons and on the sides of these hills are the old turquoise mines, appearing as saucer-like pits, from 15 to 30 feet across and of half that depth, but generally much filled up with debris. They are scattered about everywhere. Around them the ground consists of disintegrated quartz rock, like sand or gravel, full of fragments and little nodules of turquoise. Whenever the quartzite ledges outcrop distinctly they show the blue veins of turquoise, sometimes in narrow seams, sometimes in nodules or in pockets. The mode of occurrence appears closely to resemble that at Turquoise Mountain, Arizona. A few prospectors have dug into the old, half-filled depressions and found stones of good color and quality, and ordinary ones may be picked up almost anywhere out of the decomposed quartz. Stone tools are abundant in the old workings, and the indications are plain that this locality was exploited on a great scale and probably for a long period, and must have been an important source of the turquoise used among the ancient Mexicans. From an archaeological point of view this locality possesses remarkable interest. The cañon walls are full of caverns, now filled up to a depth of several feet with apparently wind-blown sand and dust, but whose blackened roofs and rudely sculptured walls indicate that they were occupied for a long time by the people who worked the mines. In the blown sand were found stone implements and pottery fragments of rude type, incised but not painted. The openings to these caves are partially closed by roughly built walls composed of trap blocks piles upon one another with no attempt at fitting and no cement, but evidently made as a mere rude protection against weather and wild beasts. The tools, found partly in the caves and largely in the mine pits, are carefully wrought and polished from hard basalt or trap, chiefly hammers and adzes or axes, generally grooved for a handle and often of large size. Some are beautifully perfect, others much worn and battered by use.

"The most impressive feature, however, is the abundance of rock carvings in the whole region. These are very varied, conspicuous, and peculiar, while elsewhere they are very rare. Some are recognizable as 'Aztec water signs,' pointing the way to springs; but most of them are unlike any others known, and furnish a most interesting problem to American archaeologists. They are numbered by many thousands, carved in the hard basalt of the cliffs, or, more frequently, on large blocks of the same rock that have fallen and lie on the sides of the valleys. Some are combinations of lines, dots, and curves into various devices; others represent animals and men; a third and very peculiar type is that of the 'shield figures', in which complex patterns of lines, circles, cross hatchings, etc., are inscribed within a shield-like outline perhaps 3 or 4 feet high.

"One curious legend still exists among the neighboring Indians that is in no way improbable or inconsistent with the facts. The story was told Mr. Eisen by 'Indian Johnny', son of the Piute chief, Tecopah, who died recently at a great age, and who in turn had received it from his father. Thousands of years ago, says the tale, this region was the home of the Desert Mojaves. Among them suddenly appeared, from the west or south, a strange tribe searching for precious stones among the rocks, who made friends with the Mojaves, learned about these mines, and worked them and got great quantities of stones. These people were unlike any other Indians, with lighter complexions and hair, very peaceable and industrious, and possessed of many curious arts. They made these rock carvings and taught the Mojaves the same things. This alarmed and excited the Piutes, who distrusted such strange novelties, and thought them some form of insanity or 'bad medicine', and resolved on a war of extermination. After a long and desperate conflict, most of the strangers and Mojaves were slain, since which time, perhaps a thousand years ago, the mines have been abandoned. Mr. Eisen connects this account with the existence of a fair and reddish-haired tribe, the Mayos (not Mayas), in parts of Sinaloa and Sonora, some of whom may have reached these mines and carried on a turquoise trade with Mexico.

[3] See 20th Rept. U. S. Geol. Surv., Min. Res., 1898, pp. 582–584; and San Francisco "Call," March 18, 1898.

"This region has since been opened at several points, and at least a dozen mines are now being worked by various parties, mostly with Eastern capital. The principal work is being done by the Himalaya and the Toltec mining companies. The turquoise obtained, when pure and of good color, is cut into fine gems; also the white and blue combination known as turquoise matrix, when small portions and veins of turquoise are distributed through the rock, and the whole is cut and polished as an ornamental stone. The paler varieties of turquoise are cut into beads, etc., long strings of which are sold. Most of the material produced is sent to New York. The yield in 1900 was estimated at a value of $20,000."

HYDROUS-SULPHATES

GYPSUM—Gypsite

H. 1.5–2; Sp. Gr. 2.31–2.32; Refractive indices, $n_{\alpha} = 1.520$, $n_{\gamma} = 1.530$.

Gypsum is a common mineral in the state, but large deposits of the mineral are exceptional. The mineral is easily formed by the action of sulphated waters on limestone.

Satin-spar and *alabaster* are two varieties which are extensively used for ornamental purposes, particularly statuary and utility boxes of various types.

Found in numerous counties throughout the state, Eakle (1), Pabst (1).

OBSIDIAN

Composition variable, contains SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O

H. 5-5.5 Sp. Gr. 2.2-2.7

Color, black, grey, brown or red, sometimes green, transparent to opaque. $n = 1.48$ to 1.67

Although due to its indefinite composition obsidian is classed as a rock or mineraloid, it is frequently cut for gem purposes. It occurs in large masses and in deposits of great extent and sometimes of considerable beauty. Small pebbles of obsidian are widely distributed and are often erroneously called 'black diamonds'.

Beautiful examples of iridescent obsidian have been found recently near Davis Creek in Modoc County; and on the east slope of Volcanic Mountain in Inyo County. This material shows fine iridescent colors on fractured surfaces and when cut and polished exhibits a pleasing chatoyance.

Glass Mountain in eastern Siskiyou County, elevation about 7,000 feet is composed almost entirely of obsidian.

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LAPIDARY ART

A simple and practical method for the cutting and polishing of gem minerals for the collection or for personal adornment

LAPIDARY ART

The widespread interest in mineral collecting has been largely responsible for the interest in the collecting and polishing of those varieties commonly called gems.

The polishing of gem minerals can be a never-ending source of pleasure due to the wide variety of species and types available. For the polishing of small specimens the apparatus required may be of the simplest nature and while excellent results can be obtained by hand methods only, the use of power-driven laps is recommended.

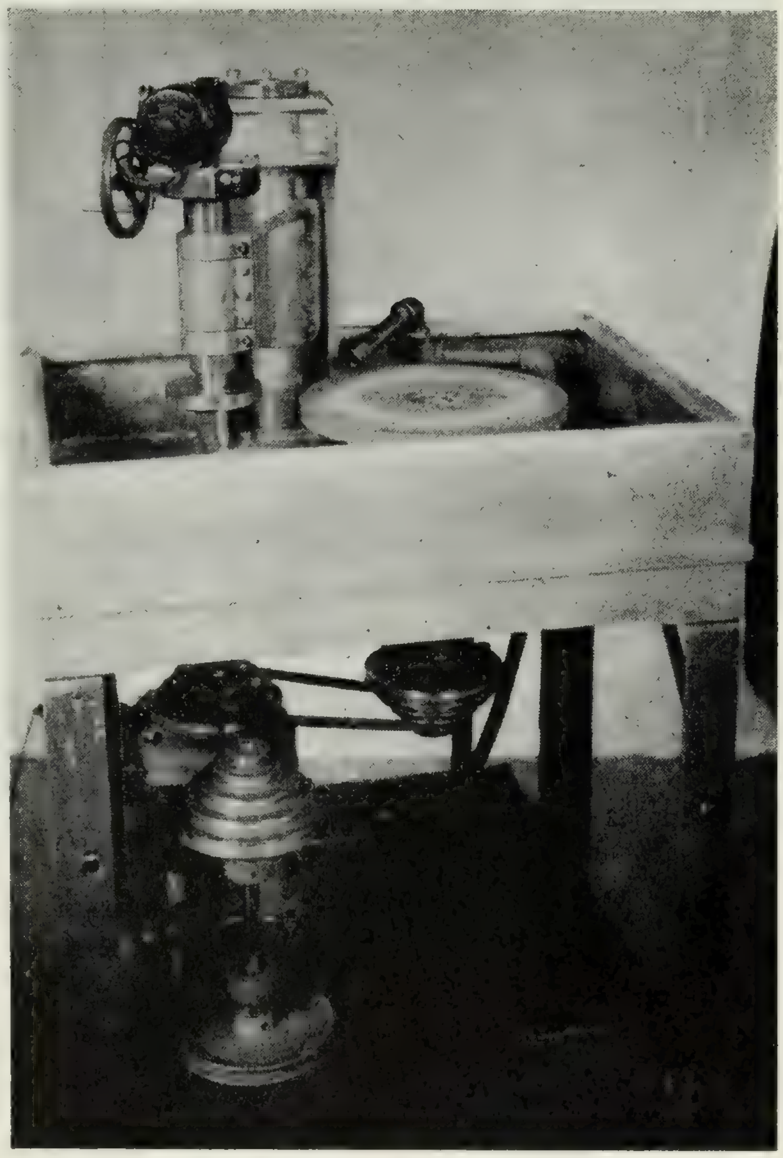

FIG. 5. Sperisen Universal Lapping and Grinding Machine.

The polishing process consists of grinding, smoothing and polishing a surface by successively finer steps with suitable abrasive materials and proper medii. The technique herein described is suitable for all stones ranging in hardness to and including beryl and tourmaline and has been used by lapidaries for decades.

The equipment required and used in the order listed follow:

Suitable grinder head with $\frac{1}{4}$ h.p. motor.

Grinding wheels, 60 K. Crystolon. Operate at 5,000 S. F. P. M.

Grinding wheels, 180 K. Crystolon. Operate at 5,000 S. F. P. M.

Abrasive cloth, 240 Crystolon. Operate at 500 S. F. P. M.

Polishing wheels, leather-covered wood drum. Operate at 1,000 S. F. P. M.

The polishing wheel consists of a depression turned in the flat side of a wooden wheel over which calfskin is stretched tightly and fastened securely. The hair or grain side being out is used as the polishing surface. The polishing medium is stannic oxide which is applied wet in the form of a wet, thin paste.

The grinding wheels are 'coarse', 60, being composed of 60-mesh abrasive, and the 'fine', 180, graded in a similar manner. The letter K designates the wheel hardness and in this case is of a medium grade. S. F. P. M. or surface feet per minute is the peripheral speed at which it has been found most economical to operate and should be maintained.

The quartz minerals are most suitable for polishing. They are abundant, being found in a great variety of colors and types and in the majority of cases of uniform texture so that results obtained by careful polishing are most pleasing and satisfactory.

Chalcedony, agate and jasper should be tried first.

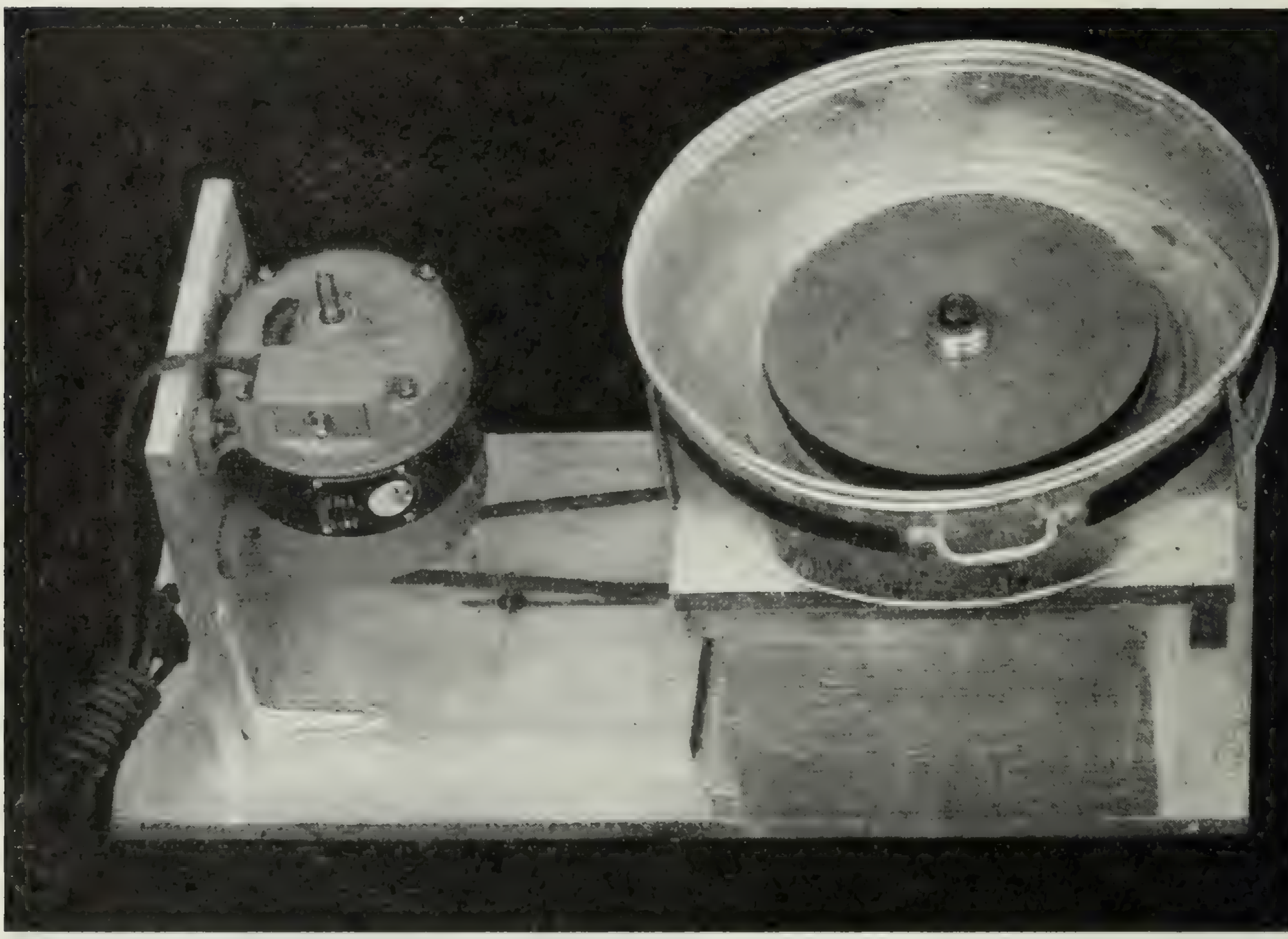

Photo by courtesy of C. W. Marwedel

FIG. 6. The Pretherick Lap.

A simple form of polished stone is known as a faced or spotted stone. This consists of polishing a face or spot on a specimen in order to bring out the color and marking.

The majority of specimens found have rough and irregular surfaces and assuming that it is desired to polish a face, the stone is first ground on the 60 K. Crystolon wheel, until a uniform surface is produced, care being exercised to remove all deep pits or fissures which may exist. The stone should be rotated so as to produce a convex surface, this being easier to polish. Flat surfaces may also be produced but these are more difficult to polish and should not be tried first.

During grinding, a copious supply of water is directed on the wheel and work. When all of the rough surface is uniformly ground the stone is ready for the second step which is similar.

Using the finer wheel, 180 K. Crystolon, the surface is further ground and it will be noticed that after grinding a minute or two, that the surface has been greatly improved, being smoother and brighter.

A magnifying glass or loupe of about 3X should be used so as to be certain that all of the deep scratches previously made by the coarser wheel have been removed. The proper preparation of a surface for polishing is of the greatest importance if best results are to be obtained.

As the following stages of smoothing and polishing remove the material very slowly, it is obvious that if deep grinding scratches exist and have not been removed, they will be plainly seen. Having produced a uniform surface with the smoother grinding wheel, the stone is next smoothed with No. 240 Crystolon cloth by briskly rubbing the face to be polished, using the cloth dry. This operation may be done equally well with the use of a wheel of wood to which the abrasive cloth has been fastened with glue. *In either case the stone is pressed against the abrasive cloth with moderate pressure.* Too great a pressure may cause overheating with the possibility of cracking. In some cases hand smoothing is preferable as it eliminates the possibility of burning, always present with the wheel method.

The surface is again examined with the 3X glass and if smooth and free of deep scratches it is ready for the final polishing.

At this stage the specimen is thoroughly scrubbed with soap and water to remove all traces of grit, a most important step. The slightest trace of grit in the polishing material will quickly ruin an excellent finish. The stone having been suitably prepared, will show a glossy surface of uniform nature and texture.

The final stage in polishing is done on the leather wheel using Tin Oxide in a paste condition *made with water and applied to the polishing* wheel with a brush, the best type being an inch-and-a-half flat varnish brush.

The stone is applied to the surface and in a few moments the wheel will be sufficiently charged to commence polishing. The time required for polishing depends on the size and type of specimen. A specimen of quartz one inch square may be completely faced and polished from the rough in 10 to 15 minutes without difficulty, the polishing time alone not exceeding five minutes.

Care should be exercised to obtain the highest degree of polish. By reflected light the high light may be examined and the dull surfaces, if any, noted. Flat surfaces may also be polished in the same manner but require a little more skill in handling.

CABOCHON CUTTING

Having mastered the art of grinding and polishing specimens, it is a natural desire to cut and polish these beautiful gem minerals into pieces suitable for personal adornment. The simplest form of gem is the Cabochon.

This is a domed shape with convex surface, the stone may have any type of geometrical outline, although it is customary to cut the stone into regular forms such as the round, ellipse, oval, rectangular, oblong, square, etc. The stone is roughed out to the desired form and size and subsequently smoothed and polished in the usual manner.

Due to the fact that the stones are usually small, they are somewhat more difficult to handle and to facilitate handling they are cemented to sticks for proper manipulation. Penholders with the top part cut off are ideal for this purpose and are inexpensive, although if preferred any round stick of equivalent size will suffice. Common red sealing-wax is used to attach the stone in place on the end of the stick, the wax is obtained in bar form and heated in a bunsen flame and a sufficient quantity is rolled on the end of the stick. The stone is heated slightly and when placed on the wax the wax is moulded about the stone until the cement has set.

Proper procedure in normal cabochon work is to finish the back of the stone first and the front of the stone finally. In reversing the stone on the stick the wax is gently heated in the flame and scraped from the stone with the aid of a knife.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes of personnel in the Division of Mines to be noted the past three months.

New Publications.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, July, 1937, being Chapter 3 of the State Mineralogist's Report XXXIII. This chapter contains: "Mineral Resources of Los Angeles County," accompanied by a map showing locations of the principal mines and the oil fields; also "Geology and Mineral Deposits of the Western San Gabriel Mountains, Los Angeles County," accompanied by a geological map.

Commercial Mineral Notes (Nos. 175-177, inc.), November, December, 1937, January, 1938, respectively. These 'Notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'CALIFORNIA JOURNAL OF MINES AND GEOLOGY.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to four pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

SUMMARY OF WORK ACCOMPLISHED

Under WPA Projects in the Division of Mines

Unpublished Material.

In the fifty-eight years since the creation by legislative statute of the State Mining Bureau (now Division of Mines of the Department of Natural Resources), there has been accumulating a library of several thousand volumes of books, magazines, and pamphlets devoted to geology, mining, chemistry, and metallurgy. Particularly in such magazines as the Mining and Scientific Press (1861-1922) and the Engineering and Mining Journal (1872-1937), there is a wealth of contemporaneous and chronological data on Californian mines, their development and operations. Lacking sufficient clerical personnel it had not been possible for the Division of Mines to index these reports so that interested engineers and others could find the data on individual mines or districts without taking up much time in searching through many volumes.

During the past two and half years, under Works Progress Administration projects sponsored by the Division of Mines, clerical and technical help has been provided, through which card-file indexes have been made for all California's mines noted or described in the above-noted magazines, listing volume number and page for each entry. These two files constitute a total of approximately 75,000 cards, and are daily consulted, being open to public use.

Similar indexes are being made of California's mines described in the bulletins and reports published by the United States Geological Survey and the United States Bureau of Mines. A total of 10,000 cards have been typed thus far, the job being now about one-half completed. A consolidated card-file index of the publications of the Division of Mines and its predecessor the State Mining Bureau is nearing completion and comprises some 45,000 cards. They cover the contents of a total of 33 annual (or biennial) reports of the State Mineralogist and 112 bulletins.

An index and revision of the bureau's bulletin on American Mining Law is being prepared, 40 chapters now being in manuscript form out of total of 60. In the book-binding section of our project, about 800 maps have been mounted on cloth, 1250 volumes repaired, and approximately 1,000 books bound in cloth and board. Mounting of the maps preserves them as they are subject to severe service in the library through frequent handling and reference use.

About 30,000 cards have been typed, indexing and cross-indexing the specimens in the mineral exhibit. This exhibit is the largest and most important of its kind west of the Mississippi River, ranking probably fifth or sixth in the entire United States. In the gold-statistics section a card index, about 6,000 cards, has been made of the names of persons who sold gold to licensed gold-buyers in 1934-1936; also over 20,000 sales receipts have been checked, arranged, and filed.

Scattered through the long list of State Mineralogist's reports and bulletins issued during the fifty-eight years of the bureau's life, are descriptions of not only the mines and deposits of the various metals but likewise of California's diversified resources of structural, industrial, and saline commercial minerals. Under our WPA project these reports have been annotated, and typewritten manuscripts prepared on the following list of commercial minerals, 24 in all thus far. These are for office reference use and copies have been supplied to the branch offices of the Division at Los Angeles, Sacramento, and Redding.

Antimony
Asbestos
Bituminous rock
Bentonite (Fuller's Earth)
Coal
Diatomite
Dolomite
Granite
Gypsum
Iron ore
Lead
Lime-Limestone
Lithia
Marble-Marl
Mica
Molybdenum
Pumice-Volcanic Ash
Pyrite
Soapstone-Talc
Slate
Sulphur
Tungsten
Wollastonite

Systematic card files are being prepared by WPA workers under the direction of the Geologic Branch of the Division of Mines. Although these files will not be published as such, they represent accumulated information, systematically arranged, to be used as working data for the Division of Mines.

In cooperation with Stanford University, sponsored by the Division of Mines, a WPA project has been preparing card files as follows:

(1) *Geographical Index.*

This index has been prepared from various maps covering the State of California. Each card represents a geographic feature, its definition and location.

(2) *Index of Fossil Localities in California.*

Each card gives information regarding the location of fossil-collecting grounds and other pertinent geologic information, together with bibliographic reference.

(3) *Annotated Bibliography of the Paleontology of California.*

(4) *General Bibliography of the Geology and Mineral Resources of California.*

In the Ferry Building, San Francisco, the following card files are being prepared under the direction of the Geologic Branch:

(1) *Mineral Deposits File.*

Each card in this file gives pertinent information abstracted from literature on the individual mineral deposits and mining claims described in publications; accurate location, dates of production, associated mineral products, types of mineralization, geological formations, significance, and bibliographic references. Of the last mentioned, duplicate cards have been made, one set arranged by county and mine, the other by mineral product and location.

(2) *Economic Mineral Deposits*

This file is developed through the evaluation of those mineral deposits which have been responsible, at some time in their history, for contributing to the State's mineral production record.

(3) *Mining Claim Index.*

The cards making up this file have been sent to the Ferry Building from our individual WPA projects sponsored by the Division of Mines and located in various County Recorder's offices throughout the State. The cards are made in triplicate form, one being left with the Division's District Engineer and the other two filed in the main office in San Francisco. Accompanying them are maps and township plats showing graphic information secured in the county recorder's offices. Tracings of patented mining claims, which are actually surveyed are being provided the Division of Mines through WPA projects located in the U. S. Land Offices in Sacramento and Los Angeles and in the office of the U. S. Cadastral Engineer at Glendale. The final drafting work is being done in San Francisco and also in the Division's Los Angeles district office.

Besides the foregoing files, other useful work has been done by WPA workers:

Map Making.

Draftsmen, provided by WPA have succeeded in preparing a large number of mining claim plats, and township plats showing the location of mining claims and also a number of maps and charts of geological interest.

Preparation of Lantern Slides.

Many hundreds of lantern slides of salient geological and mineralogical features of California have been prepared through help provided by WPA.

The foregoing indexes, files, maps, etc., all represent work accomplished or in part yet to be completed which of themselves will not be put in published form for sale or distribution. They are all available, however, for reference use of the interested public and the Division's technical staff, and for the preparation of future geological or mineral resources reports.

Publications.

Three outstanding publications are the result of the work done under the direction of the Geologic Branch of the Division of Mines which could not have been done without the clerical and drafting assistance provided by the Federal Public Works Administration and the Works Progress Administration. One of these is the new State Geologic Map of California, on a scale of 1:500,000 (8 miles per inch), issued in 6 sections, showing geologic formations, so far as they are known, throughout the entire State. A grant of $5,000 was first issued by the Federal Public Works Administration and dispensed through the U. S. Geological Survey. With this money competent geological draftsmen were employed to work under the special direction of the Chief Geologist of the State Division of Mines. Before this map went to the lithographer, however, many marginal maps, charts, legends, etc., were prepared for it by WPA draftsmen.

A new book, "Minerals of California," is now in press and will soon be ready for distribution as Bulletin No. 113 of the Division of Mines. Preparation of this book by Dr. Adolf Pabst, Associate Professor of Mineralogy at the University of California, was made possible by the clerical assistance provided by the WPA.

Another new book, the "Bibliography of the Geology and Mineral Resources of California," by Dr. Solon Shedd, of Stanford University, is now in press and will be issued as Bulletin No. 115 by the State Division of Mines. The preparation of this book was made possible by the clerical assistance provided by the federal WPA.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

CALIFORNIA MINERAL PRODUCTION FOR 1937 SHOWS INCREASE

The total value of the mineral production of California for the year 1937, just closed, is conservatively estimated by the Statistical Section as $351,487,000. This is partly detailed in the tabulation below, but as there are more than 50 mineral substances on California's commercial list, figures on the most important items only are available at this early date. The production report forms are being mailed to the operators in all mineral lines, and the detailed and complete report will be compiled and published later.

The estimated total of $351,487,000 is an increase of approximately $23,683,000 over the 1936 production total value, and is the largest since 1929. The principal increases in value of output over those of the previous year were shown by petroleum, gold, natural gas, brick and hollow building tile, silver, copper, lead, and quicksilver. The only important mineral substances to register decreased values were miscellaneous stone and cement.

The value and amount of the petroleum output showed an increase over that of 1936, with a total quantity of about 237,666,000 bbls., an increase of about 11 per cent over that of 1936. There was little or no change in the price paid to producers by the refineries, although production increased in the lighter-gravity crude oils which bring higher prices. There was an increase in the amount of natural gas utilized thereby increasing its total value over that of the previous year.

Receipts of bullion at the mint and smelters showed an increased output of gold of some 87,000 fine ozs. Thus 1937 had the highest annual gold value since 1861, and the largest in fine ounces since 1862 with the exception of 1883. All other major metals on the California commercial list showed an increase in output with the exception of zinc. The silver and copper yield each had a total value over the million dollar mark.

Of the structural group practically all materials showed an increased production and value, with the exception of cement and miscellaneous stone. These declines brought the total value of this group to show a net decline from that of 1936. Building permits in 51 principal cities of the state increased 7½ per cent over the previous year. Both the miscellaneous industrial and the saline groups showed small changes in their total values.

The estimated values and quantities for 1937 are as follows:

$40,740,000	(1,164,000 fine ozs.) gold.
2,209,000	(2,865,000 fine ozs.) silver.
1,268,000	(10,480,000 lbs.) copper.
152,000	(2,500,000 lbs.) lead.
791,000	(9,200 flasks) quicksilver.
350,000	other metals including chromite, iron ore, platinum, tungsten ore, etc.
240,000,000	(237,666,000 bbls.) petroleum.
18,724,000	(302,000,000 M. cu. ft.) natural gas.
17,023,000	(12,073,000 bbls.) cement.
9,980,000	crushed rock, sand, and gravel.
2,300,000	brick and hollow building tile.
1,450,000	other structural materials, including bituminous rock, granite, magnesite, marble, sandstone, slate, etc.
5,000,000	miscellaneous industrial materials.
11,500,000	salines, including borates, potash, iodine, salt, soda, etc.
$351,487,000	total value.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20816 DAKEITE, a hydrous carbonate and sulphate of calcium and uranium. From the desert of Wyoming.
Donor: Minnie McCormick, Wamsutter, Wyoming. October, 1937.

20817 BARITE ($BaSO_4$), Barium sulphate.
From 16 miles from Battle Mountain, Nevada.
Donor: H. C. Auston. November, 1937.

20818 CINNABAR (HgS) with CALCITE ($CaCO_3$) and PYRITE (FeS_2), deposited either as replacement of organic roots or stems, or the filling of tubes in sandstone.
From Oceanic Quicksilver Mine, near Cambria, San Luis Obispo County, California.
Donor: Mr. O'Boyle. October, 1937.

20819 SCHEELITE ($CaWO_4$), calcium tungstate.
From Rossi Tungsten Mine near Bishop, Inyo County, California.
Donor: B. W. Holeman. August, 1937.

20820 CHROMITE ($FeCr_2O_4$)—a very good grade ore.
From Bear Chrome Mine, Rock Creek, Plumas County, California.
Donor: Louie Eddelbethel. November, 1937.

20821 ELLESTADITE (pale rose-pink). A complex lime-silicate similar to Wilkeite. From Crestmore, Riverside County, California.
Donor: John Melhase. November, 1937.

20822 BARITE 'Roses'—barium sulphate ($BaSO_4$).
From Norman, Oklahoma.
Donor: Charlie Hansen. November, 1937.

20823 BARITE ($BaSO_4$)—barium sulphate. Mined at a depth of 200 feet below surface.
From Devil's Gulch, Mariposa County, California. November, 1937.

20824 STIBNITE (Sb_2S_3)—well crystallized.
Found in cache about 13 miles from Alleghany, Sierra County, California.
Donor: William H. Cogley. December, 1937.

20825 AXINITE—a borosilicate of aluminum and calcium, with iron and manganese. From the Humbug Mining District, Siskiyou County, California.
Donor: C. B. Kay. December, 1937.

20826 STIBNITE (Sb_2S_3), antimony ore. From Prathier Mine, Reese River Mine District, Lander County, Nevada.
Donor: E. B. Hodges. December, 1937.

20827 ALTAITE (PbTe), lead telluride.
From Hill Top Mining Co., 18 miles northeast of Las Cruces, New Mexico.
Donor: F. W. Meneray. January, 1938.

20828 STIBNITE (Sb_2S_3) both crystalline and fine; granular massive.
From Stayton Mine, San Benito County, California.
Donor: Ross Kesser. January, 1938.

20829 CHROMITE—about 65 per cent CrO_2. Crystallized.
From New Caladonia, a French Colony in the Antipodes.
Donor: Al Leschot. January, 1938.

20830 CHROMITE. This will grind up to a fine powder.
From New Caladonia, a French colony in the Antipodes.
Donor: Al Leschot. January, 1938.

20831 STELLERITE ($CaAl_2Si_7O_{18}.7H_2O$), a rare Zeolite.
From San Diego County, California.
Donor: J. D. Nichols. January, 1938.

20832 Muscovite MICA. From near Council, Idaho.
Donors: A. H. Huntington and L. H. Albee. January, 1938.

20833 ALUNITE, a hydrous sulphate of aluminum and potassium.
From Cactus Range, Inyo County, California.
Donor: Death Valley Curly. January, 1938.

LABORATORY

Frank Sanborn, Mineral Technologist

Prospecting for and development of California's mineral wealth appears to increase rather than decrease as the state grows in population. During the year, 1937, approximately 7200 samples were received and identified at this laboratory. Also, additional information and help was given to more than a hundred miners and prospectors who sought information on recovering gold and platinum from sluice box concentrates, on detecting tungsten in an ore, and many other problems.

The detection of the calcium tungstate, scheelite, by its fluorescence is very interesting and practical, and we have already given instructions and demonstrations on this method of prospecting to a number of miners. Anyone desiring information on the detection of scheelite by the ultra-violet ray may call at our laboratory where it will be given by a practical test.

Assistance in finding a market for minerals is given to those who make such a request. Those who desire to sell a mineral should submit a small sample of it to this department when help is wanted in finding buyers.

LIBRARY

J. C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE ESPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Water Supply Papers:

679 B Thermal Springs in the U. S.
796 C Flood in La Canada Valley, Calif., January 1, 1934.
797 Selected Bibliography on Erosion and Silt Movement.
809 Part 9, Colorado River Basin.
811 Part 11, Pacific Slope Basins in California.
812 Part 12, Pacific Slope Basins in Washington and Upper Columbia River Basins.
817 Water Levels and Artesian Pressure in Observation Wells in the U. S. in 1936.

Bulletins:

895 A Geophysical Abstracts, 88, January-March, 1937.

Topographic Sheets:

Banner Hill, Quadrangle, Nevada County.
Bouldin, Quadrangle, Nevada County.
Chatswood, Quadrangle, Los Angeles County.
Fairmont, Quadrangle, Los Angeles County.

Isleton, Quadrangle, Los Angeles County.
Ivanpah, Quadrangle, California-Nevada.
Little Tujunga, Quadrangle, Los Angeles County.
Manzana, Quadrangle, Los Angeles County.
Mount Baden-Powell, Quadrangle, Los Angeles County.
Palo Alto, Quadrangle, Los Angeles County.
Red Rover, Quadrangle, Los Angeles County.
Reef Ridge, Quadrangle, Los Angeles County.
San Francisquito, Quadrangle, Los Angeles County.
Sunland, Quadrangle, Los Angeles County.
Swarthout, Quadrangle, Los Angeles County.
Waterman Mountain, Quadrangle, Los Angeles County.

U. S. Department of Agriculture, Forest Service:

Los Padre National Forest (Except the Monterey Division).
West Half, Mt. Diablo and San Bernardino Meridians.
Los Padre National Forest, East Half, Mount Diablo and San Bernardino Meridians.
162 A Vegetation Types of California, Tujunga Quadrangle.
163 B Vegetation Types of California, Rock Creek Quadrangle.

U. S. Bureau of Mines:

Information Circulars:

6948 Aerial Tramways in the Metal-Mining Industry, Part 1. By O. H. Metzger.
6949 Shaft- and Slope-Bottom Lay-Outs at Coal Mines. By Robert L. Anderson.
6950 Mining and Reduction Methods and Costs at the Oceanic Quicksilver Mine, Cambria, San Luis Obispo County, California. By A. W. Frolli.
6955 Smelting Ores in the Electric Furnace. By R. S. Dean and M. W. von Bernewitz.
6957 Some Results of First-Aid Training of All of the Employees of a Mine or Plant. By J. J. Forbes.
6958 What's Wrong With Mine Safety Programs. By D. Harrington.
6959 Some Aspects of Strip Mining of Bituminous Coal in Central and South Central States. By Albert L. Toenges and Robert L. Anderson.
6960 Sampling and Testing of a Gold-Scheelite Placer Deposit in the Mojave Desert, Kern and San Bernardino Counties, California. By H. W. C. Prommel.
6961 Placer Operations of Humphreys Gold Corporation, Clear Creek, Colo. By E. D. Gardner and Jos. R. Guiteras.
6962 Mining and Grinding Methods and Costs at the Malvern Clay Co. Mine, Malvern, Ohio. By E. J. Lintner.
6963 Mining Methods and Costs of the Quartz Hill Mining Co., Dewey, Mont. By S. H. Lorain.
6964 Reconnaissance of Mining Districts in Clark County, Nevada. By Wm. O. Vanderburg.
6965 Ventilation at the Anthracite Collieries of the Northern Pennsylvania Field. By G. E. McElroy.
6966 Occurrence and Treatment of Mercury Ore at Small Mines. By M. W. von Bernewitz.
6967 Methods and Costs of Mining & Crushing Gypsum at the Mine of the Victor Plaster, Inc., Victor, N. Y. By E. J. Lintner.
6968 Pebble-Phosphate Mine Accident Experience. By Frank E. Cash and Claud P. Dempsey.
6969 Some Suggestions on Safety in Coal-Mine Haulage. By C. A. Herbert.
6970 Liquid Carbon Dioxide Used to Extinguish a Gob Fire in a German Coal Mine. By Geo. S. Rice and Irving Hartmann.
6971 Methods and Costs of Mining and Crushing Gypsum at the Mine of the Ebsary Gypsum Co., Inc., Wheatland, N. Y. By E. J. Lintner.
6972 Gold Lode Mining in the Tobacco Root Mountains, Madison County, Montana. By S. H. Lorain.
6973 Annual Report of the Mining Division for the Fiscal Year 1937. By Chas. F. Jackson.
6974 Annual Report of the NonMetals Division, Fiscal Year 1937. By Oliver C. Ralston.

6975 Milling Methods and Costs at the Mill of the Tom Reed Gold Mines Co., Oatman, Ariz. By Paris V. Brough.
6976 Operations and Costs at the St. Joe Mining & Milling Co., Boulder, Colorado. By Jos. R. Guiteras.
6977 Petroleum Refineries, Including Cracking Plants in the U. S. By G. R. Hopkins and E. W. Cochrane.
6978 Mining Methods and Costs at the Mount Isa Mines, Ltd., Mount Isa, Queensland, Australia. By J. Kruttschnitt and V. I. Mann.
6979 Electric Signaling System, Ross Shaft, Homestake Mining Co. By John F. Wiggert.
6980 Use of Reflector Buttons for Danger, Warning, Direction and Safety Signs in Mines. By F. E. Griffith and H. J. Van Der Veer.
6981 Coal-Mine Fires of Electrical Origin; Their Cause and Prevention. By E. J. Gleim.
6982 Pumping Operations in the Cripple Creek District, Colo. By Jos. R. Guiteras.

Report of Investigations:

3352 A Method of Determining Porosity: A List of Porosities of Oil Sands. By D. B. Taliaferro Jr., T. W. Johnson and E. J. Dewees.
3353 Earth Vibrations Caused by Quarry Blasting, Progress Report I. By J. R. Thoenen and Stephen L. Windes.
3354 Hardening of Mud Sheaths in Contact with Oil, and a Suggested Method for Minimizing Their Sealing Effect in Oil Wells. By C. P. Bowie.
3356 Sulphuric Acid Extraction Methods for Determining Olefins and Aromatics in Hydrocarbon Oils. Optimum Conditions and Concentrations of Acid. By C. H. Fisher and Abner Eisner.
3357 Progress Reports—Metallurgical Division. 20. Annual Report of the Metallurgical Division, Fiscal Year 1936-37. By R. S. Dean and Others.
3360 Bureau of Mines Midget Impinger for Dust Sampling. By J. B. Littlefield, Florence L. Feicht and H. H. Schrenk.
3361 Active List of Permissible Explosives and Blasting Devices Approved Prior to June 30, 1937. By J. E. Tiffany, Explosives Division, Bureau of Mines Experiment Station, Pittsburgh, Pa.
3362 Properties of California Crude Oils, V—Additional Analyses. By E. C. Lane and E. L. Garton.
3364 Progress Reports—Metallurgical Division.
21: Studies in Nonferrous Metallurgy.
Collection of Gold by Iron Abraded in Grinding. By S. R. Zimmerley.
Flotation of Oxidized Silver-Lead Ores As Influenced by Modified Grinding. By S. R. Zimmerley.
3366 Mineral Economics Series: 2. Consumption of Ferrous Scrap and Pig Iron in the United States in 1936. By Robert H. Ridgway, H. W. Davis, and M. E. Trought.
3374 Cooperative Fuel Research Motor-Gasoline Survey, Summer, 1937. Compiled by E. C. Lane.

U. S. Bureau of Mines:

Technical Paper 577, Chemistry of the Anhydrous Chlorides of Chromium. A Thermodynamic Investigation. By H. A. Doerner.

Books:

Annual Report of Director of the Mint, 1937.
Annual Report of the Smithsonian Institute, 1936.
Colorado School of Mines, quarterly, January, 1937.
Engineering Index.
General Alphabetical and Analytical Index, American Institute of Mining and Metallurgical Engineers.
Geophysical Studies, 1932-1936.
Handbook for Prospectors, 3d Edition, M. W. Von Bernewitz.
The Hoover Policies. By Ray Lyman Wilbur and Arthur M. Hyde.
Metal Quarry Catalogs, including Directory of Manufacturers, 1938, McGraw-Hill Catalog Service.
Mines Register, Successor to The Mines Handbook, 1937 Edition.
The Mineral Industry during 1936, Vol. 45.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon Bureau of Mines and Geology, Corvallis.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers. New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.

Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nickel Cast Iron News, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Moscow, Idaho.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Petroleum World, Los Angeles.
Pit and Quarry, Chicago.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.

San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California
Western Mineral Survey, Salt Lake City, Utah
Western Sentinel, Etna Mills, California.

Books.

Land Use Programs of Public Agencies in California Organization Personnel, History and Objectives.
Gold Deposits of the World. By Wm. Harvey Emmons.
Minerals Yearbook, 1937, U. S. Dept. of the Interior.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	$0.70
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	.70
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	---- 1.15
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	1.25
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913-1914, Fletcher Hamilton:	
Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	.60
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.60
Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	.35
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	.50
Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	.60
Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915:	
A General report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	3.00
Chapters of the State Mineralogist's Report, Biennial Period, 1915-1916. Fletcher Hamilton:	
Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	.75
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.55
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	$0.75
Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	.60
Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	.75
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper	.90
Mines and Mineral Resources of Plumas County, 188 pp., paper	.60
Mines and Mineral Resources of Sierra County, 144 pp., paper	.60
Seventeenth Report of the State Mineralogist, 1920. 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	2.00
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, November, December, 1922	.30
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	.30
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy	.30
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.30
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.30
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.30
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.30
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California', Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.30
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.35
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.30
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.35
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.30
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County	.30
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.30

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
April, 1928, Mines and Mineral Resources of Mariposa County	$0.30
July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	.30
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.30
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.35
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.35
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.35
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.35
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.30
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	.35
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	.35
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradlley. Published quarterly:	
January, 1931, Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete	.35
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island	.35
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931	.30
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.35
April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	.35
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)	.25
July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a Part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist	.65

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Chapters of Report XXIX, 1933 (quarterly: titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic Map showing various mines and prospects of part of Del Norte and Siskiyou Counties	$0.90
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming. Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543	.90
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits	.50
April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores	.90
October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas	.50
Chapters of Report XXXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation	.50
April. A Geologic Section Across the Southern Peninsular Range of California. New Technique Applicable to the Study of Placers. Grubstake Permits	.50
July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights	.50
October. Mines and Mineral Resources of San Luis Obispo County. Mineral Resources of Portions of Monterey and Kings Counties. Mining Activity at Soledad Mountain and Middle Buttes—Mojave District, Kern County. Geology of a Portion of the Perris Block, Southern California. Mineral Resources of a Portion of the Perris Block, Riverside County	.50
Chapters of Report XXXII, 1936 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Gold Mines of Placer County, including Drag-line Dredges. Geologic Report on Borax Lake, California	.50
April. Geology, Mining and Processing of Diatomite at Lompoc, Santa Barbara County. Essentials in Developing and Financing a Prospect into a Mine. Gold-bearing Veins of Meadow Lake District, Nevada County. Semi-Precious Gem Stone Collection in Division Museum	.50
July. Mines and Mineral Resources of Calaveras County. Mining in California by Power Shovel. Assessment Work on Mining Claims Within Withdrawn Areas. Joshua Tree National Monument. Cost	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
of Producing Quicksilver at a California Mine in 1931-1932. The Age of Mineral Utilization	$0.50
October. Mineral Resources of Lassen and Modoc Counties. Mechanics of Lone Mountain Landslides, San Francisco. Biennial Report of the State Mineralogist, Properties and Industrial Applications of Opaline Silica	.50
Chapters of Report XXXIII, 1937 (quarterly) : titled 'California Journal of Mines and Geology,' containing the following:	
January. Source Data of the Geologic Map of California, January, 1937. The Geology of Quicksilver Ore Deposits. Prospecting for Lode Gold	.50
April. Mineral Resources of Plumas County (with Geologic Map). List of preferred mineral names. New Placer Mining Debris Law	.50
July. Mineral Resources of Los Angeles County (with map showing principal Mines and Oil Fields.) Geology and mineral deposits of the Western San Gabriel Mountains, Los Angeles County	.50
Subscription, $2.00 postpaid in advance (by calendar year only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, **June, **July, **August, **September, **October, **November, **December, 1919	----
**January, **February, **March, **April, **May, **June, **July, **August, **September, **October, **November, **December, 1920	----
January, **February, **March, April, **May, **June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, **July, **August, September, **October, **November, December, 1922	Free
January, February, **March, **April, May, **June, **July, August, September, **October, November, **December, 1923	Free
January, February, March, April, May, June, **July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, **May, June, July, August, September, October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
(Published quarterly beginning July, 1929)	
January-February-March, April-May-June, July-August-September, October-November-December, 1930	Free
January-February-March, April-May-June, July-August-September, 1931	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1932	Free
January, February, March, 1933	Free
April, May, June, 1933	Free
July, August, September, 1933	Free
October-November-December, 1933	Free
January-February-March, 1934	Free
April-May-June, 1934	Free
July-August-September, 1934	Free
October-November-December, 1934	Free
January-February-March, 1935	Free
April-May-June, 1935	Free

BULLETINS

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**Bulletin No. 1. A description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
Bulletin No. 4. Catalogue of California Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887)	$0.10
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	.75
Bulletin No. 10. A Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	.50
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	.10
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means, 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms, 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	.10
Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	.10
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	.75
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
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Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

Vol. 34 — APRIL, 1938 — No. 2

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXIV

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

57814

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·STATE MINERALOGIST·
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Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer.

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco field district are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

Reports covering the mines and mineral resources of most of the counties in the Los Angeles field district are now available, and field work at present is confined to investigations for special reports upon Inyo, and Mono counties.

REDDING FIELD DISTRICT

GOLD DREDGING IN SHASTA, SISKIYOU AND TRINITY COUNTIES

Chas. Volney Averill, Mining Engineer

Introduction.

The price of $35 per fine ounce for gold, which has now been in effect for four years, has stimulated all types of gold-dredging. In northern California, during those same years, the development of the dragline dredge into an efficient machine for the recovery of placer gold has been an important factor in the growth of the industry. The dragline dredge has been called a 'doodlebug' by many persons, but this is not considered an appropriate name by the writer, and it is not used here.

The name dragline dredge is used in this article to denote a placer mining outfit composed of two separate and distinct units. The digging is done by a standard make of dragline shovel, which travels on the ground by means of caterpillar tracks under its own power. The heavy bucket, which picks up from one cubic yard to three cubic yards of gravel at one time, is suspended by a steel cable from a structural-steel boom roughly 50 ft. in length. Washing of the gravel is accomplished on the second unit, which is a barge floating in a pond. For washing out the gold, the barge carries a revolving screen and riffle-tables similar to the standardized units used on the larger dredges. The dragline shovel digs away at the edge of the pond, which thus advances. To cause the barge to follow, a pull on cables anchored on the shore is all that is needed. The tailing discharged from a belt-conveyor and sand-sluices fills up the pond behind the barge.

The standard type of dredge, on which the digging is done by means of a bucket-elevator comprising a chain of heavy buckets, each of which is connected by a round pin to the next one, will be called here a bucket-ladder dredge. The ladder is the heavy structural steel member that supports the bucket-chain.

It is not the purpose of this article to indicate that the dragline dredge is in any way superior to the bucket-ladder dredge. The writer believes that the dragline dredge has opened up a new field to dredging, namely those deposits that are too small to justify the construction of a bucket-ladder dredge. If a deposit is large enough and contains enough gold to amortize the capital investment in a bucket-ladder dredge, and return a suitable profit, probably a dragline dredge should not be considered. Bucket-ladder dredges have been made portable to a certain extent, and may be used on more than one deposit, but the dragline has the advantage in this regard. The operating cost per cubic yard is roughly the same on the smallest bucket-ladder dredges as it is on the largest draglines.

The dragline dredge has the following disadvantages:

1. The maximum depth to which they have worked in this district is

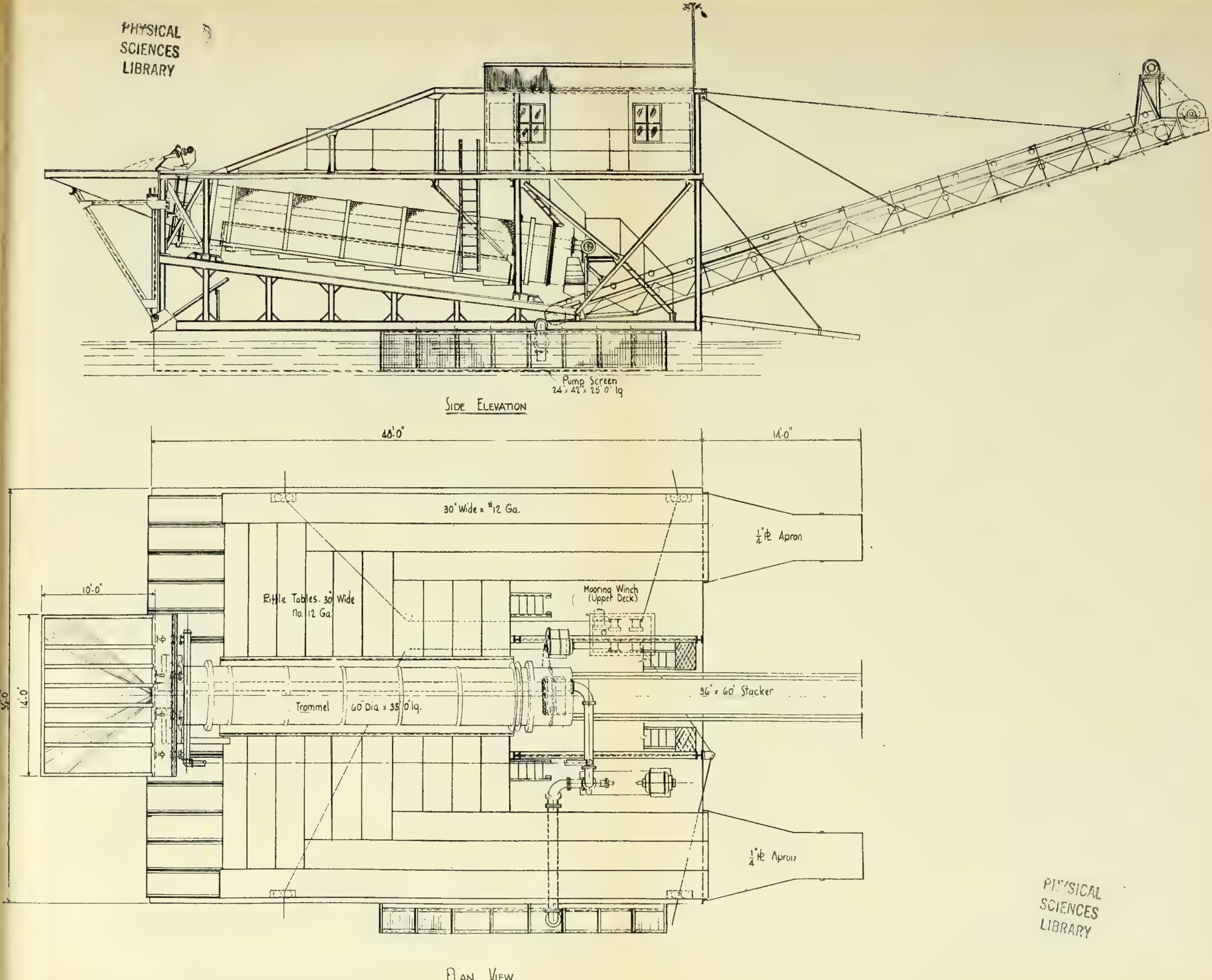

FIG. 1. Dragline dredge. (Cut by courtesy Bodinson Mfg. Co.)

roughly 20 ft. Possibly this can be extended somewhat with the largest shovels with very long booms.

2. They will not dig gravel that is hard and compact or partly cemented as well as a bucket-ladder dredge.
3. Bedrock must be soft. No dredge is successful where bedrock is very hard and irregular, but a bucket-ladder dredge will dig harder rock than a dragline.

Subject to favorable conditions regarding depth, ease of digging, and soft bedrock, dragline dredges are successful on deposits too small for bucket-ladder dredges for the following reasons:

1. Less capital is needed to purchase the dragline shovel and washing-plant.
2. The dragline dredges are smaller and float in very shallow ponds because the heavy digging-machinery is not on the barge.
3. The dragline shovel and the tractor with 'bulldozer' blade, which is now practically a standard item of equipment, can quickly throw up small dams so that the barge can be placed on various terraces and in small tributaries higher than the main channel. If necessary, water for the pond is pumped.
4. When one small deposit has been worked out, the modern outfit with barge of steel-pontoon construction can be quickly moved to another deposit. Such a move involving dismantling and re-erection has actually been made in a week's time with the regular crew.

Logan[1] and Magee[2] have written articles on dragline dredges. Since those articles were written, washing plants have been much improved, larger units have been put in service, and cost per cubic yard has been much reduced.

'Dry Land' Dredges.

At least a dozen dredging outfits of the so-called 'dry-land' type have been built in northern California in recent years. Most of them were so poorly designed and constructed that they had no chance to succeed, and were used for very short periods. Even the best of them have been built on timber skids to be pulled forward by the power shovel. Gravel accumulates under the skids, irregular bedrock interferes, and much time is lost in moving. Another common fault is tailing-sluices on trestles, which must be rebuilt every time a move is made. Lack of head-room often results in the tailing backing up against the rear end of the washing plant. Most of these outfits are built of second-hand material including second-hand gasoline engines. Contrast this with the latest dragline dredges, which are built of new material of excellent quality, and which are powered by diesel engines or electric motors. Gasoline engines may be considered obsolete for dragline dredging. Diesel engines soon pay for themselves in fuel savings.

[1] Logan, C. A., Placer mining in California with power shovels: Calif. State Mineralogist's Report XXXII, pp. 373-377, 1936.

[2] Magee, J. F., A successful drag-line dredge: Amer. Inst. Min. Met. Eng. Technical Publication No. 757, pp. 1-16, 1936.

A few outfits of the 'dry-land' type have been operated successfully in other states. One of these in which the washing-plant is on special steel wheels running on rails has been described by Ross and Gardner.[1] Another in which gravel is screened in a plant mounted on a caterpillar track, which moves under its own power alongside two dragline shovels, and in which fines are pumped to a separate gold-saving plant through 8-inch pipe and hose, has been described by Gardner and Guiteras.[2] Even with good design and good management, costs per cubic yard at these plants are higher than for the latest dragline dredges described below. The dragline dredge has the advantage that the floating plant follows the shovel with a minimum of lost time.

In another type of operation, gravel is loaded on trucks and hauled to a stationary washing plant. Cost per cubic yard is higher (20 cents to 25 cents per cubic yard and up) than for any other type mentioned here. The washing plant is soon practically buried in its own tailing. A successful operation of this type is described briefly in State Mineralogist's Report XXXI.[3]

Acknowledgments.

The writer wishes to acknowledge the cooperation of all operators of dredges named on the following pages; also of E. J. Quinn, Bodinson Manufacturing Co., San Francisco; H. A. Sawin and C. M. Romanowitz. Yuba Manufacturing Co., San Francisco; Walter W. Johnson Co., San Francisco.

Areas Being Dredged.

A word about the old cry that dredging renders land useless for agriculture may not be out of place. In general it may be said that lands now being dredged in northern California are worthless for agriculture before being dredged as well as after. Suppose that the owner of any typical piece of dredging land receives 10% of the gross value of the precious metals recovered from the tract as his share or royalty. If he will invest this money even at present low interest rates of 2% and 3%, he will have a greater annual income than he could have obtained from the land in any other way.

One large dredging company invested a part of its profits from dredging in reclaiming a tract of land elsewhere for agricultural use. The tract so developed was much better suited to agriculture than the tract that was dredged. This scheme can be followed if a shortage of agricultural lands exists, but such a shortage does not exist at present.

Dragline dredging has been very active in the vicinity of Redding, especially to the southwest at distances ranging from a few miles to 35 miles by road. In Trinity County draglines are working on tributaries of Trinity River near Douglas City and Weaverville, and at Hayfork. Bucket-ladder dredges are located as follows: three on Trinity River near Junction City and Lewiston, two just outside of Yreka, one

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[1] Ross, C. L., and Gardner, E. D., Placer-mining methods of E. T. Fisher Co., Atlantic City, Wyo.: U. S. Bur. Mines Inf. Circ. 6846, pp. 1-11, 1935.

[2] Gardner, E. D., and Guiteras, J. R., Placer operations of Humphreys Gold Corporation, Clear Creek, Colo.: U. S. Bur. Mines Inf. Circ. 6961, pp. 1-16, 1937.

[3] Averill, C. V., Mines and Mineral Resources of Siskiyou County, Klamath Placer Mining Co.: Calif. State Mineralogist's Report XXXI, pp. 294-296, 1935.

on Scott River at Callahan, and one on Roaring River southwest of Redding.

Geology

A few details of the geology of the dragline field southwest of Redding will be given because conditions are nearly ideal for this type of dredging. Gravels being dredged are in the channels of present streams and on low terraces adjacent to the present channels. The gravel is seldom more than 10 ft. in depth, and most of it is loose enough so that it is not difficult to dig.

Beneath the gravels of the present streams are sediments of Tertiary and Cretaceous age, all of which form soft bedrock that the dragline buckets can dig. Several inches to a foot of it are usually taken up to recover gold lying on bedrock. To the west of the Pacific Highway for a distance of 10 to 15 miles, the Tertiary bedrock is a clay-like volcanic tuff dipping below horizontal at small angles to the east. Gravels of the Pleistocene Red Bluff formation overlie the tuff in large areas, and they should not be confused with gravels of present streams. Apparently no concentration of gold occurs in these widespread Red Bluff gravels. In the vicinity of Gas Point, the bedrock changes from Tertiary on the east to Cretaceous formations toward the west. The Cretaceous dips east at a steeper angle, roughly 20°. It comprises shales, sandstones and conglomerates in general harder than the Tertiary tuff, but a layer near the top is decomposed and is soft enough for easy digging.

The gold has no doubt been carried over these sedimentary formations from an origin in the igneous rocks, schists, and older sediments to the north and west. Clear Creek is one of the principal streams and it passes through the French Gulch [1] district, well known for its rich quartz veins. Erosion of these has unquestionably contributed gold to the placer deposits. In the vicinity of Igo is a deposit of gravel covering many acres to depths reaching 100 ft. It is apparently an old terrace of Clear Creek, now high above the present stream. Part of it has been mined by drifting and hydraulicking. Part of it has not yet been mined. Dry Creek and its tributaries, now being extensively dredged with draglines, dissect the old Clear Creek terrace, and gold has been carried out by Dry Creek and over Cretaceous and Tertiary bedrock. Hence the placer gold of Dry Creek is derived largely from an older placer deposit.

Some persons have thought of the Cretaceous conglomerates as a possible source of the gold, and it is possible that some of the beds of Cretaceous conglomerate contain gold. However, an examination of the boulders in the placer deposits shows that many are larger than those found in the conglomerates, and that they have apparently been washed in by streams originating in the igneous rocks and schists, and in the older Bragdon conglomerate (Carboniferous). The bulk of the gold must have been washed along with them. Quartz veins in the Bragdon conglomerate are gold-bearing at French Gulch.

[1] Averill, C. V., Gold deposits of the Redding and Weaverville quadrangles (including map): Calif. State Mineralogist's Report XXIX, pp. 3-73, 1933. Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California (including map): Calif. State Mineralogist's Report XXIX, pp. 77-122, 1933.

Platinum-group metals are produced as a byproduct from Roaring River near Gas Point and from other properties between there and Cottonwood; also from Hayfork. The metal carries roughly 30% iridium, which gives it a high value per ounce. The osmiridium grains are a bright silvery-white in color, and are inclined to be flat in shape because of a natural cleavage. Some of them show sharp angles instead of the rounded forms of softer metals. They are hard enough to scratch glass readily. This metal has no doubt been derived from bodies of serpentine. One large dike of serpentine is known on Cottonwood Creek west of Ono. Others probably exist farther west in areas of which the geology has not yet been mapped in detail.

Prospecting.

Nothing is more important to the success of a dredging operation than to determine in advance that the tract in question contains enough gold, and possibly platinum, to return a profit. The usual way of proceeding is to put down a few holes at widely spaced intervals, and determine the gold content per cubic yard. If the results are encouraging, a line of holes across the channel at wider than normal spacing is put down. If the results are still good, intermediate holes are put down in this line, and other lines of holes are sampled at regular intervals along the channel.

In general, holes put down by a drill of the Keystone type are most widely used. Casing is driven a foot or two at a time, the gravel inside the casing is cut with the bit, and is then bailed out into a bucket or tub for panning. Gold from panning should be weighed on an assay-balance, and an occasional fire assay should be made to determine the fineness of the gold. If necessary, a drop of quicksilver can be used in the pan to collect fine gold. The quicksilver is dissolved in nitric acid, then the gold is washed and dried, and weighed as usual. Volume of the gravel is calculated as a cylinder of the depth drilled and diameter equal to the outside diameter of the cutting shoe on the casing. A variation of this method is described by Ross and Gardner in Information Circular 6846 of the U. S. Bureau of Mines, previously cited. Details on the latest types of drills suitable for this work may be obtained from Keystone Driller Co., Beaver Falls, Pennsylvania, and from C. Kirk Hillman Co., 111 Sutter Street, San Francisco, California.

In shallow deposits such as are suitable for dragline dredging, it is often possible to dig shafts or pits by hand at low cost. The choice between this method and drilling is affected by the depth at which water flows into the hole. Some operators recover the gold from all of the gravel removed from such a shaft or pit by washing the gravel twice in a rocker. Others cut a channel a foot long and a foot wide for the depth of the hole, and wash the gravel removed from the cut twice in a rocker. Gravel from different depths is treated separately to determine which strata contain the gold. To a limited extent tracts have been prospected for dragline dredging by digging pits with a dragline shovel. The sample is cut from the side of the pit, a vertical channel one foot square in plan.

The spacing and the number of holes depend on how uniformly the gold is distributed through the gravel. It is likely to occur in

streaks as the deposit is viewed both in plan and in vertical section. Unless the distribution has been proved to be more uniform by several rows of closely spaced holes, this erratic occurrence of the gold should be assumed, and the prospecting should be planned accordingly.

DRAGLINE SHOVELS

Dragline shovels of such standard makes as Bucyrus-Erie, Lima, Link Belt, Koehring, Marion Northwest, P. & H. and Thew-Lorain are in use for dragline dredging. Details of various sizes, speeds and horsepower may be obtained from the manufacturers. Thoenen[1] has tabulated some of these data in Information Circular 6798 of the U. S. Bureau of Mines. Fairly high digging and swinging speeds are desirable for this type of work, and hence fairly high horsepower. Most of the shovels in northern California are equipped with $1\frac{1}{4}$-cu. yd. and $1\frac{1}{2}$-cu. yd. buckets, but those of 3-cu. yd. capacity more recently put in service give a lower operating cost per cubic yard. The $1\frac{1}{2}$-cu. yd. shovels have 50-ft. booms, and the 3-cu. yd. shovels have 60-ft. booms. Different lengths are obtainable if they are needed to fit different conditions.

Buckets.

Both Page and Esco buckets are in use. The Esco with five teeth will dig harder gravel than the Page, but it dumps more slowly. A set of teeth is usually dulled each shift, and must be built up by welding.

Power.

The shovels with $1\frac{1}{2}$-cu. yd. buckets for which cost-data are given below are powered by D-13000 Caterpillar diesel engines rated at a maximum of 130 horsepower. The 3-cu. yd. shovel is powered with a 200-hp. electric motor.

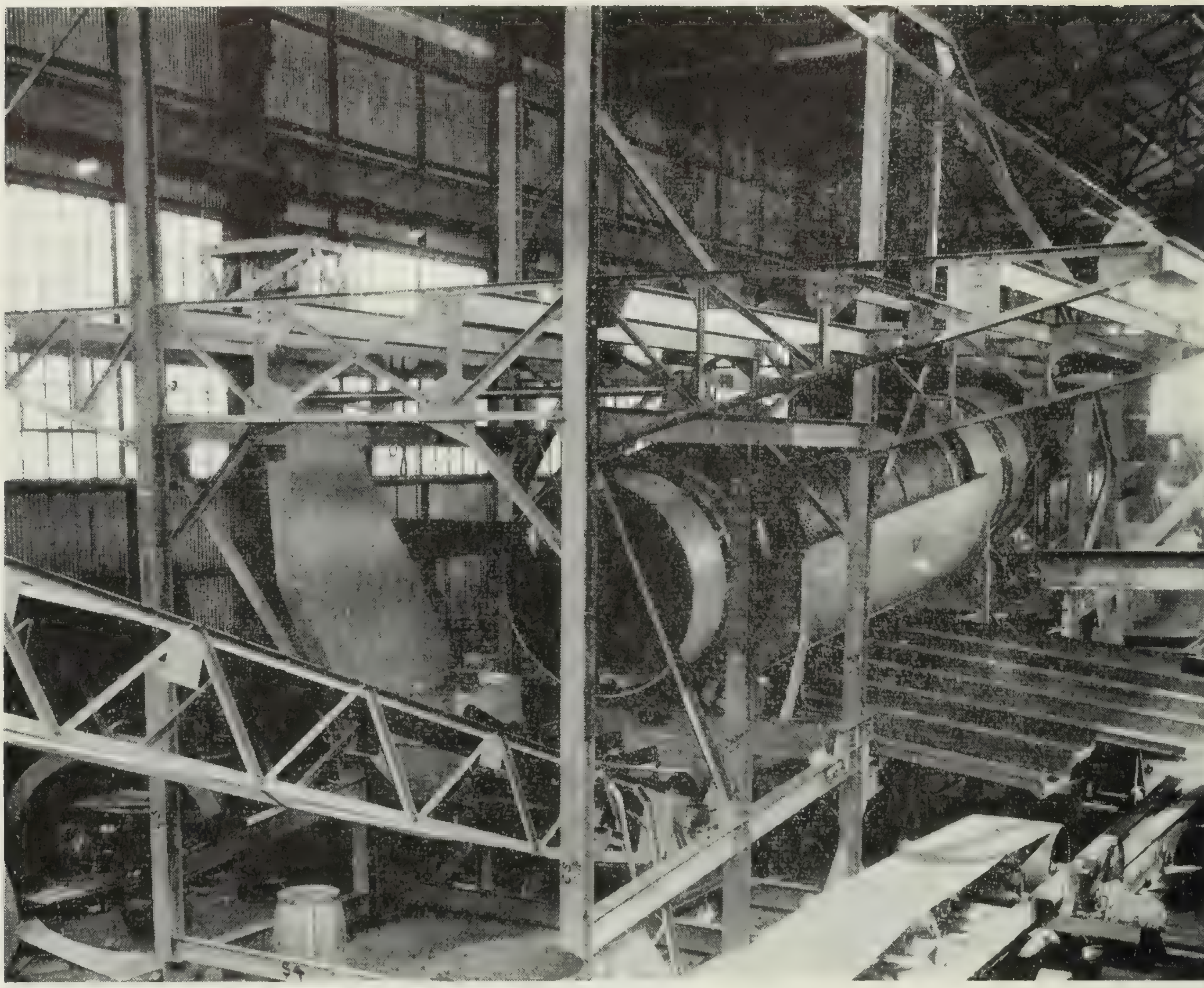
Digging Methods.

Two general methods of digging are in use. The common method is to move the shovel in the direction of the channel, and reach to each side as far as possible with the boom. Each cut is twice as wide as the boom is long, roughly 100 ft. By utilizing the momentum of the swing, the operator can cast the bucket a little beyond the end of the boom. The other method is to move the shovel across the channel, thus placing the caterpillar tracks at right angles to the direction of the digging-cable. Wider cuts are possible with this method, and its advocates state that bedrock is cleaned better. This seems reasonable, because in the method mentioned first the arc through which the bucket moves causes a strip of bedrock to remain uncleaned toward the extreme reach of the boom. This can be avoided to a certain extent by overlapping the cuts, but the digging is done under muddy water, and accuracy of this overlap is difficult to attain.

Mats.

While the shovel can usually travel on the ground in dry weather, when the ground is muddy or very sandy, mats are needed. These are made by bolting together timbers, about 8 by 10 inches, in sections four

[1] Thoenen, J. R., Sand and Gravel Excavation, Part I: U. S. Bur. Mines Inf. Circ. 6798, pp. 23-39, 1934.



PHOTOGRAPH 1. Dragline dredge under construction in shop, showing trommel and parts of riffle-sluices and stacker-ladder. (Photo by courtesy Bodinson Mfg. Co.)

feet wide and somewhat longer than the width of the tread of the shovel. The boom is used as a crane to pick these up behind the caterpillar tracks and put them down in front.

TRACTORS

A tractor of the caterpillar type powered by a diesel engine is now practically a standard item of equipment in both dragline dredging and bucket-ladder dredging. It is usually equipped with a scraper or bulldozer blade in front and often has a winch mounted in back. The principal use is for clearing the land of brush and trees. These are either pushed or pulled to one side or piled for burning. Many jobs of handling heavy parts are possible with the tractor, and it is useful in building dams for some locations of the dredge-pond. In dragline dredging, the tractor and bulldozer are particularly useful for smoothing the way ahead of the shovel, so that the latter can be moved ahead with a minimum of lost time. The tractor and a Le Tourneau carryall have been used in a few places to remove several feet of soil overburden containing no gold.

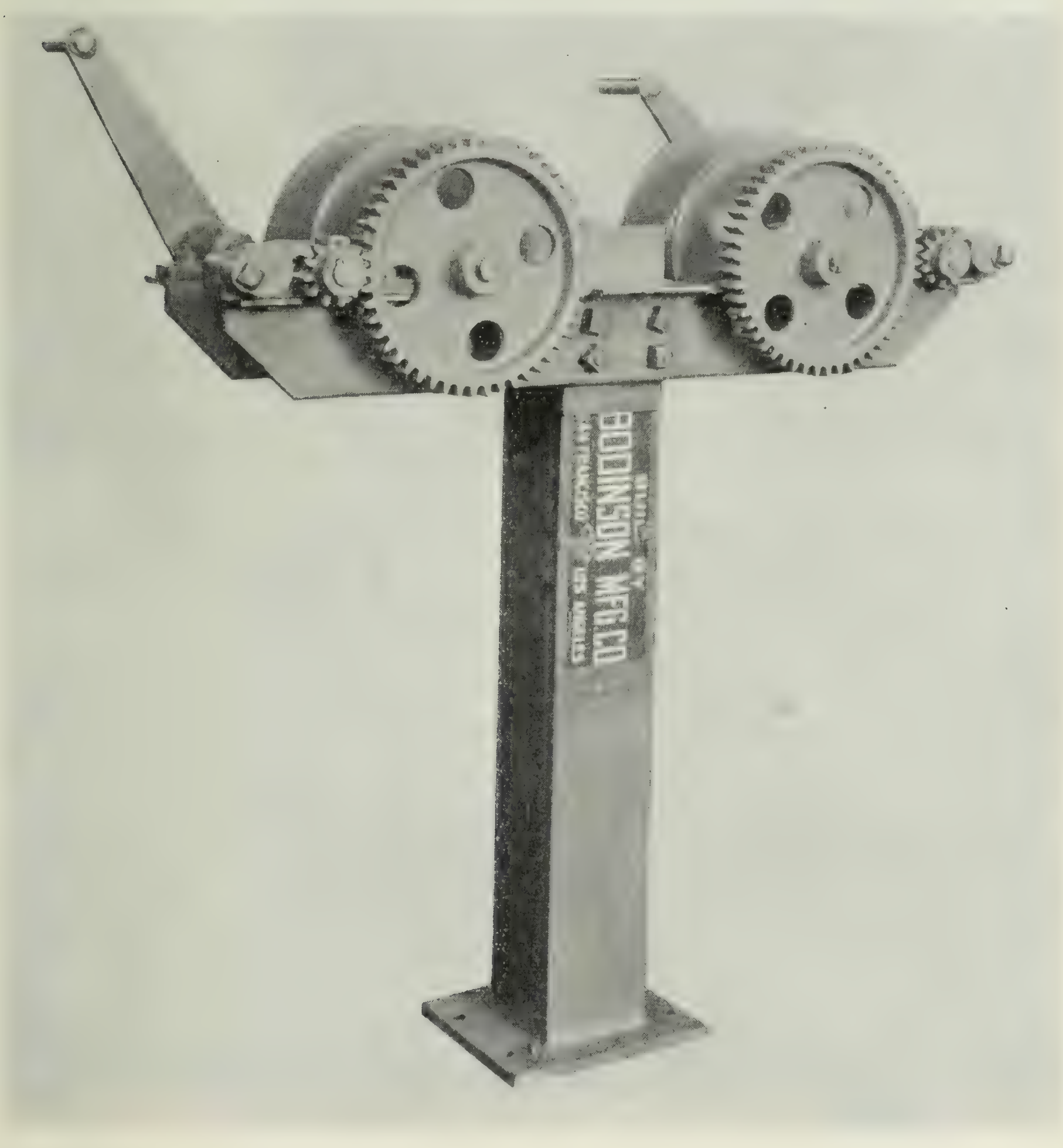
WASHING PLANTS

The washing-plant for a dragline dredge is mounted on a barge, and consists of a hopper into which the gravel is dumped by the shovel, a revolving screen or trommel, and a belt-conveyor to stack the coarse tailing behind the barge. Large streams of water are pumped from the

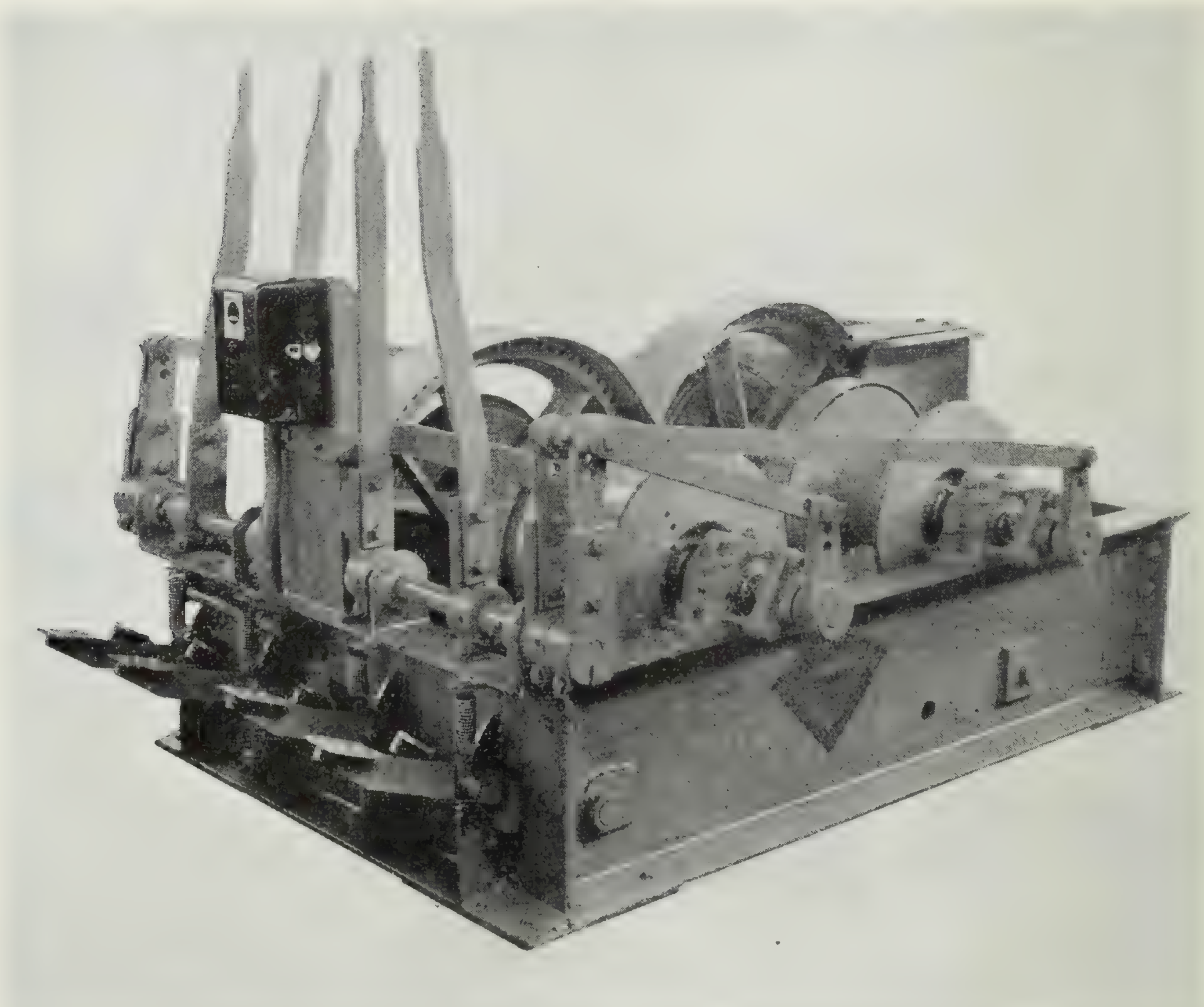
pond into both the hopper and the trommel. The sands that pass through the screen are washed on inclined tables, which are divided by partitions into a number of sluices containing riffles to retain the gold. The washed sand flows into the pond behind the barge. The following descriptions of details have been generalized somewhat to cover practice in the district, but they are given with the particular plants in mind for which cost-data are tabulated below. The all-steel plants are made by Bodinson Manufacturing Co., 2401 Bayshore Boulevard, San Francisco. Welded joints are used throughout. Even the corrugated iron housing is tack-welded to the steel frame.

Hulls.

The barge for a $1\frac{1}{2}$-cu. yd. outfit is 30 ft. by 40 ft. and is made of five pontoons, each 8 ft. by 30 ft. by 42 inches deep. For the 3-cu. yd. outfit, it is 35 ft. by 48 ft. by 42 inches deep, and comprises six pontoons, each 8 ft. by 35 ft. Steel is $\frac{3}{16}$-inch thick, and all seams are electric-welded. Well braced frames for pontoons are made of $2\frac{1}{2}$-inch by



Photograph 2. Hand-winch for dragline dredge. (Photo by courtesy Bodinson Mfg. Co.)



PHOTOGRAPH 3. Power-winch for dragline dredge. (Photo by courtesy Bodinson Mfg. Co.)

2½-inch by $\frac{3}{16}$-inch angles. The earlier barges were made of timber frames covered with 3-inch planks, and a number of these are still in use.

Winches.

The barge is pulled ahead and swung to distribute tailing by means of cables anchored ashore and attached to winches on the barge. Hand winches are used on the smaller outfits and power-winches on the larger ones. On a plant serving a 3-cu. yd. electric shovel the winch is driven by a 3-hp. electric motor.

Hopper.

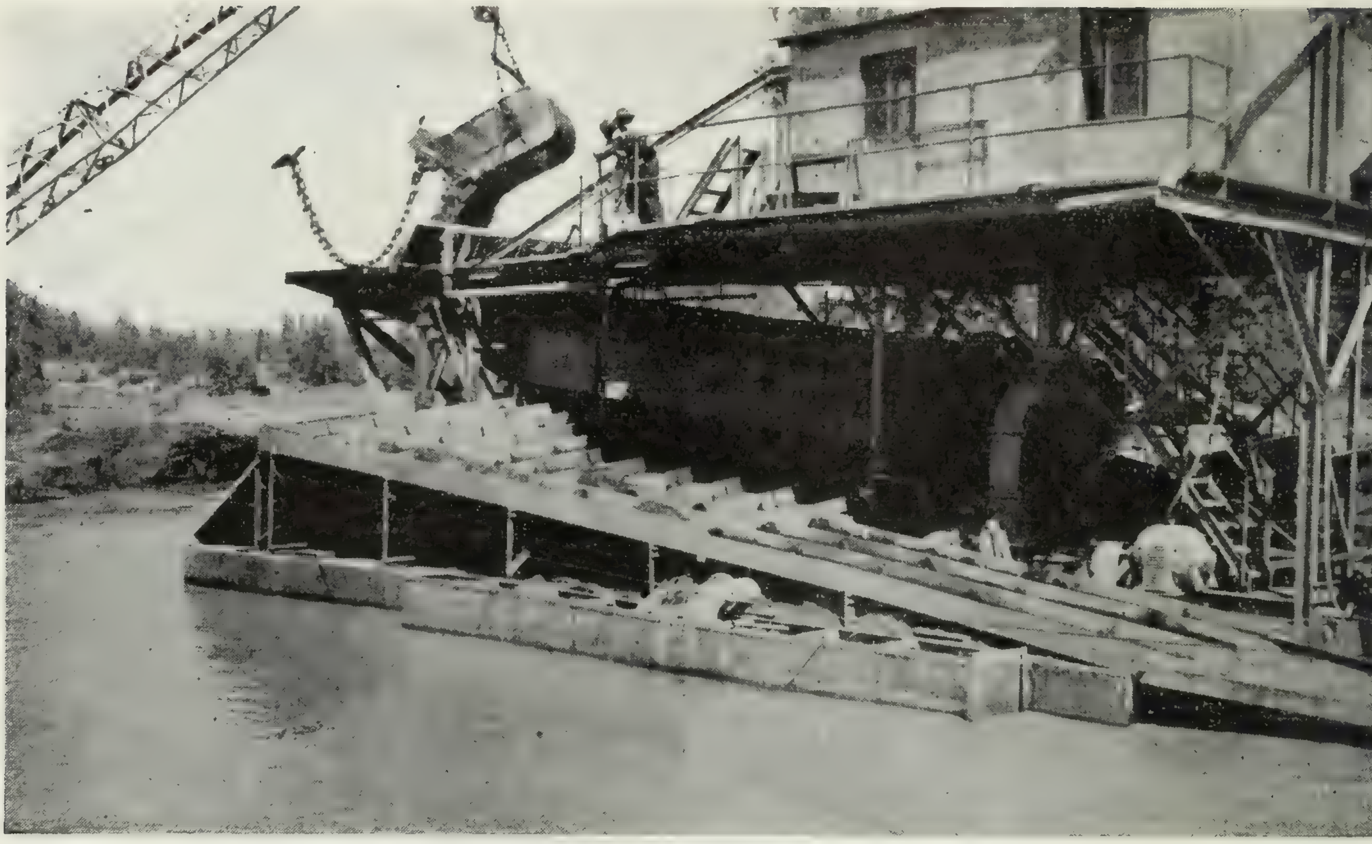
A heavy hopper usually made of ½-inch steel plates welded together receives the gravel dumped from the dragline bucket. A grizzley of 90-lb. steel rails spaced at 16-inch centers prevents large boulders from entering the trommel. An effort is made to lay aside with the shovel any boulders that will not pass through this grizzley because on plants operated in this district facilities for handling boulders on the barge are not good. A new design to be mentioned later overcomes the difficulty. Water is discharged from nozzles into the hopper. On the 3-cu. yd. outfit, the hopper is 14 ft. by 10 ft. and is 13 ft. 11½ inches above the deck.

Trommels.

Details given here are for the plants on which cost-data are given below. Different sizes of holes and different spacing can be used as required by the particular deposit being worked. For the $1\frac{1}{2}$-cu. yd. outfits, trommels are 24 ft. long by 54 inches in diameter. Two end sections of 4 ft. each are not perforated. Other sections of 4 ft. each are perforated as follows: first, $\frac{3}{8}$-inch holes with $1\frac{1}{4}$ inches metal between; second, $\frac{3}{8}$-inch holes with $\frac{3}{4}$-inch metal between; last two, $\frac{1}{2}$-inch holes and $\frac{1}{2}$-inch metal between. They turn at 14 revolutions per minute. On the 3-cu. yd. outfit, the trommel is 35 ft. long by 5 ft. in diameter. End sections of 5 ft. each are not perforated. The balance of 25 ft. is perforated with $\frac{3}{8}$-inch holes, but the spacing varies in the 5-ft. sections as follows: on the first section $1\frac{1}{4}$ inches of metal is left between holes; second section, $\frac{3}{4}$-inch; last three sections, $\frac{3}{8}$-inch. The speed of rotation is 12 rpm. A pipe drilled with $\frac{5}{8}$-inch holes extends through the trommel, and water is sprayed from it to wash the gravel.

On the older outfits, the metal housing around the lower half of the trommel ended a few inches above the riffle sluices, and water and sand dropped directly on the riffles. On the Bodinson washing plants, the trommel housing is carried several inches below the level of the riffles into a narrow, depressed steel box running the full length of the trommel. This is provided with baffles or weirs to regulate the flow to the different sluices. It serves also as an effective trap to retain coarse gold. To recover this at cleanup time, large pipe-plugs in the bottom are unscrewed.

PHOTOGRAPH 4. Trommel for dragline dredge on truck and trailer.



PHOTOGRAPH 5. Dragline dredge showing trommel, riffle-sluices, pump and pump-screen.

Riffle-Tables.

On the 3-cu. yd. outfit are 10 sluices with riffles on each side of the trommel. They are all 30 inches wide, 12 are 14 ft. long, and 8 are $11\frac{1}{2}$ ft. long. They discharge into a pair of sluices of the same width on each side of the barge, running lengthwise of the barge to discharge at the stern. The lower portions of these sluices are provided with riffles also. In the upper portions, where the sluices running crosswise of the barge discharge into them, too much turbulence exists for riffles to be effective. The trommel and all sluices are set at a grade of $1\frac{1}{2}$ inches to a foot. Some designers use $1\frac{1}{4}$ inches to a foot. On the smaller barges for $1\frac{1}{2}$-cu. yd. shovels, the arrangement is the same, except that dimensions are reduced to correspond with those of the barge.

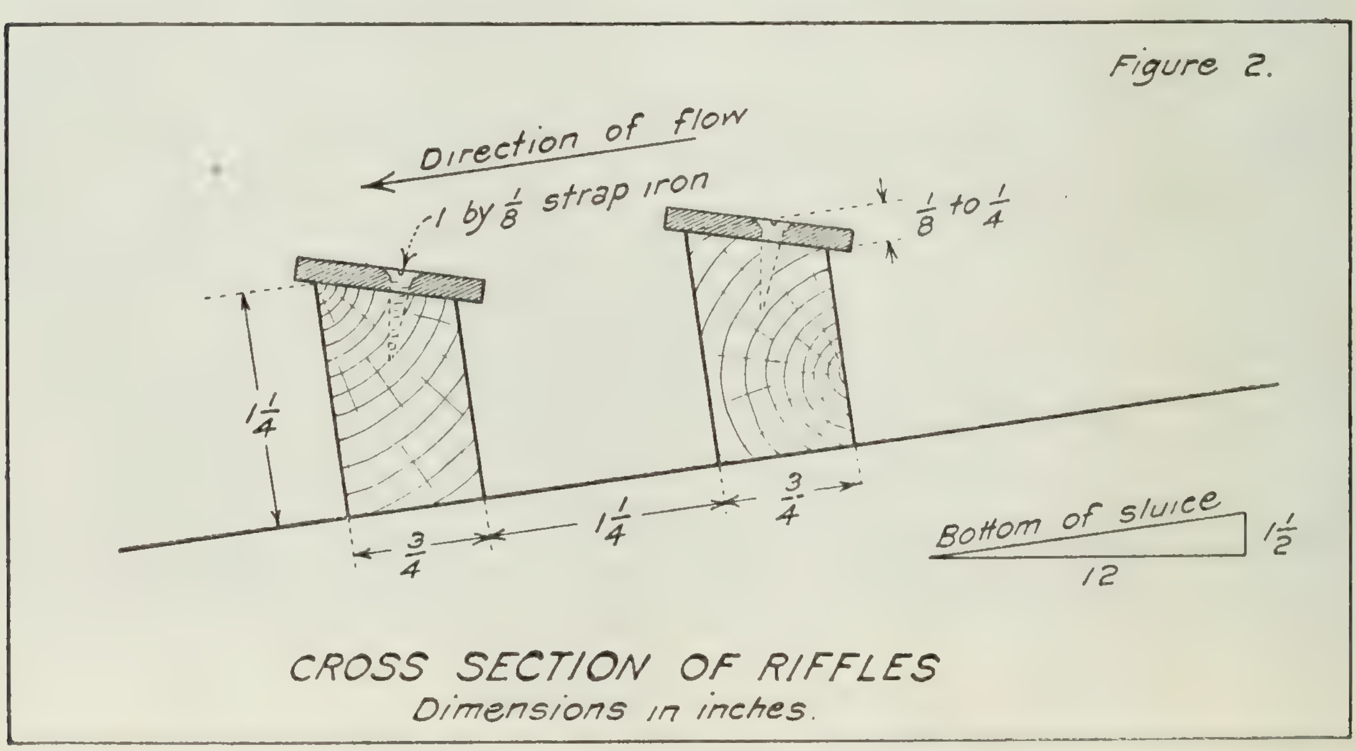


FIG. 2. Cross section of dredge-riffles.

Riffles are of the Hungarian dredge-type of wood, $1\frac{1}{4}$ inches deep, $\frac{3}{4}$-inch wide, spaced at $1\frac{1}{4}$ inches. They are made up in sections of a length equal to the width of the sluice, and about a foot along the direction of flow. These small sections are easily handled during the cleanup. The top of the wood is beveled off for $\frac{1}{8}$ inch to $\frac{1}{4}$ inch, so that the top is nearly level when the riffle is in the sluice. It is shod on top with strap iron, 1 inch by $\frac{1}{8}$-inch, held in place with countersunk wood screws. On the Roaring River dredge described on a later page, rubber is substituted for iron. Both the rubber and the iron are wider than the wood beneath, and overlap the wood a little on both edges.

Most operators use expanded metal lath of one-inch mesh over burlap, coconut matting or English corduroy in the upper half of the sluices running crosswise of the barge, that is just beneath the trommel.

PHOTOGRAPH 6. Dragline dredge under construction in field.

The metal lath is raised with tongue-and-groove flooring so that the top is even with the top of the riffles in the lower part of the sluice. Quicksilver is sprinkled on this at the start of each shift, and the metal lath holds the quicksilver close to the under side of the flow of sand and water, where it is more effective in amalgamating the gold than in the deeper riffles.

Stackers.

For stacking the coarse tailing behind the barge, the $1\frac{1}{2}$-cu. yd. plant is equipped with a belt-conveyor system, 50 ft. long between pulleys, with a 30-inch belt. The stacker for the 3-cu. yd. plant is 50 ft. long with a 36-inch belt. Some of the boats with diesel power have an electric generator and motor so that the stacker can be driven by the upper pulley. One plant has the upper pulley driven by a shaft running the full length of the stacker.

Power.

On one of the $1\frac{1}{2}$-cu. yd. outfits for which cost-data are given below, power is furnished by a D-7700 Caterpillar diesel engine rated at 50 hp. on continuous sustained loads or 63 hp. maximum; on the other by a D-8800 Caterpillar diesel engine rated at 64 hp. and 80 hp. respectively. Electric lights are furnished by 2000-watt Koehler plants.

Power on the 3-cu. yd. outfit is furnished by the following electric motors: 50 hp. on pump, 30 hp. on trommel, 10 hp. on stacker, 3 hp. on winch and 5 hp. on auxiliary pump.

Water.

During the first half of the year, for which cost figures are given below, practically all water needed was obtained from the natural flow of the streams. During the dry season, impounded water bought from a company which furnishes water primarily for irrigation may cost $500 per month total for all three outfits.

Water for washing the gravel on the barges is pumped from the pond on the $1\frac{1}{2}$-cu. yd. outfits with a 7-inch centrifugal pump. The 3-cu. yd. plant has a 10-inch pump discharging into the hopper and trommel; also a 4-inch auxiliary pump to supply additional water to the sluices. The 4-inch pump is used to furnished water for cleaning up the riffles. The proportion of water and sand is variable according to the character of the ground being mined. The mixture of sand and water discharged at the stern of the barge is roughly 10% to 15% solids.

Delays.

The plants are kept in operation 24 hours per day. "Operating hours" listed below include only that time in which the shovel was digging gravel and delivering it to the hopper on the barge. All other time is counted as delays. These include time for moving, for lubricating and servicing the shovel and other machinery, repairs and cleanups.

For a move to a new location involving dismantling of equipment, seven days are required for the $1\frac{1}{2}$-cu. yd. outfit, and eight days for the 3-cu. yd. outfit. The regular crew of roughly 14 men is used in either case. As extensive replacements of worn parts are usually made at this time, an accurate estimate of the cost of such a move is not available. Parts and cost of installing them should be charged to maintenance and not to moving. In such a move, the shovel is used as a crane to pick up a pontoon or other heavy part and load it on a truck and trailer. It is interesting to note that $1,000 should be ample to cover the cost of dismantling and re-erection when the length of the truck-haul is moderate.

Cleanups.

Cleanups probably average about once a week. Some operators could no doubt improve their recovery by watching the condition of the riffles more closely and cleaning up when the riffles are loaded instead of at regular intervals. One operator who uses expanded metal lath over burlap near the trommel cleans up the lath after every 80 hours of running time, and makes 80% to 90% of his total recovery

in this way. The metal lath is taken up, then the concentrate on the burlap is hosed off into a tub. To clean it thoroughly, it is finally held in a vertical position over the tub and hosed again. When the Hungarian riffles are cleaned up, the sections about one foot in length are taken up one at a time, and lighter sands are washed overboard with a hose. Amalgam and several tubs full of the heavier sands are saved for further treatment. This treatment varies with different operators, and long toms, tables of the Wilfley type, and amalgamation-barrels are all in use. Amalgam is squeezed and retorted, and the resulting sponge-gold is ready for the mint.

One operator who recovers platinum makes the final concentration by panning, dries the concentrate, and blows away the last of the sand. The metal is then treated with nitric acid, washed and dried, and sold to platinum-buyers.

Experiments are under way to treat the entire sand content of the riffles from each cleanup. One of these contemplates table-concentration followed by passing the concentrate through molten lead. Another method is to dry the sand and use dry concentration with mechanical blowers.

Crew.

The crew employed on the three outfits for which cost-data are given below comprises the following: 18 men on barges, 9 on shovels, 3 oilers, 3 tractor-drivers, 3 mechanic-welders, 3 extras used as truck-drivers, etc., one cleanup man, and one superintendent. This crew of 41 men operates the three plants for 24 hours per day.

Capital Investment.

The following figures are intended to give a rough idea of the principal items of equipment of high quality and bought new.

	1½-cu. yd. diesel	3-cu. yd. electric
Shovel	$22,000	$30,000
Barge and washing plant	20,000	28,000
RD7 Caterpillar tractor, diesel	6,500	
RD8 Caterpillar tractor, diesel	------	8,000
Attachments for tractor (bulldozer, winch)	------	3,300
Miscellaneous welding, etc.	1,500	1,700
	$50,000	$71,000

In addition to these main items, the following may or may not be needed depending on the location and other variable conditions: truck, shop, camp, stock of spare parts, electric power line and transformers, storage for diesel fuel. A shop of some kind is usually provided. It may contain a part or all of the following: welding equipment, machine tools, retort for amalgam, machinery for cleaning sands, and possibly for recovery of platinum.

Operating Costs.

The following figures on operating costs, covering the first six months of 1937, were furnished by the auditor of an experienced operator who had been in the business for some time. All of the equipment was bought new for the purpose of dragline dredging and had been in

operation for an average of about a year before January 1, 1937, when the period covered below starts. Depreciation of $1,000 per month on each outfit is charged by the operator with the idea in mind that the machinery runs continuously, as near 24 hours per day as possible, not intermittently like equipment used by a contractor. The figures are believed to be accurate, but with less accuracy in the figure for cubic yards than in the others. Yardage was calculated on the basis of an actual survey for area, but depths were estimated. The costs per cubic yard are representative of those being claimed by a number of operators with considerable experience, and using high-class equipment.

The lower cost per cubic yard for the 3-cu. yd. electric is due chiefly to the fact that a much larger yardage is handled by the same size of crew as is used on the smaller outfits. The cost per cubic yard for power is a fraction of a cent lower on the electric.

	1½-cu. yd. diesel	1½-cu. yd. diesel	3-cu. yd. electric
Gravel handled, cubic yards	394,050	330,900	696,000
Cost of Operation.			
Shovel, payroll	$4,659.10	$4,003.38	$4,269.20
Fuel oil, lubricating oil, gasoline	1,500.00	1,471.38	57.03
Maintenance	1,405.58	1,264.15	889.96
Cable	592.73	777.03	1,394.97
Direct expense	8,157.41	7,515.94	6,611.16
Washing-plant, payroll	5,283.11	4,489.94	6,307.50
Fuel oil, gasoline	1,255.00	1,278.68	160.39
Maintenance	877.22	825.73	949.48
Direct expense	7,415.33	6,594.35	7,417.37
General operation			
Power	--------	--------	3,599.13
Water	--------	--------	159.00
Repair, labor and materials, including clearing of land with tractors	8,282.11	7,658.11	8,301.89
Compensation insurance	586.70	593.26	585.62
	8,868.81	8,251.37	12,645.64
Office, taxes, general	1,001.00	875.39	948.80
Depreciation	6,000.00	6,000.00	6,000.00
Total operating expense, 6 months	$31,442.55	$29,237.05	$33,622.97
Cost per cubic yard	0.08	0.088	0.048
Operating hours	2,175	2,489	2,686

No land-costs and no royalties are included in these figures.

New Designs.

Bodinson Manufacturing Co., San Francisco, is now building washing plants for dragline dredging which include newly designed equipment of two kinds. On one of these is special equipment for handling boulders. Means of transporting these from the grizzley lengthwise of the top of the superstructure on the barge are provided. The boulders are discharged through either of two chutes at the stern, arranged to drop them in the pond just clear of the stacker.

In another new design of an outfit of 3000 cu. yd. rated daily capacity, jigs will be substituted for riffle-sluices. Four rougher jigs

will be carried on each side of the barge, and their concentrate will be treated in two cleaner-jigs. Overflow from the cleaners will go back to the roughers. Discharge launders running lengthwise of the barge will be equipped with riffles only as a check on jig operation. Ahead of the jigs will be nugget-traps consisting of a depressed trough containing a perforated pipe for its entire length. Water discharged from the perforations will keep the sand in motion. One consideration in the installation of these jigs is the recovery of platinum.

Jigs are each 3 ft. 6 inches square. They are of a special design called the Bodinson-Heath, and are actuated by oil-cylinders working on a diaphragm. One advantage of this design is a saving of head room.

BUCKET-LADDER DREDGES

Bucket-ladder dredges, called also bucket-line dredges, bucket-elevator dredges, and bucket-chain dredges, on which the heavy digging machinery forms a part of the floating equipment, had already reached a high degree of perfection 20 years ago when Janin [1] described them in a 226-page bulletin of the U. S. Bureau of Mines. This bulletin is still useful but it is out of print. It may be consulted in many large libraries. However, designers of dredges have not been idle during the past 20 years; and Janin's bulletin could be considerably revised and extended to cover recent improvements. Only short descriptions of the most important of these will be attempted here. A few additional new developments are mentioned in connection with individual dredges recently built in northern California. They are described on later pages under the names: Junction City Mining Co., Roaring River Gold Dredging Co., Yreka Gold Dredging Co., and Yuba Consolidated Gold Fields.

So much has been learned about special methods of taking care of the great strains to which a dredge is subjected, and of combating excessive wear caused by the abrasive material handled, that the design of a dredge is a matter for experts. Dredges designed by others are likely to break down so often, and lose so much time in which production of gold should be taking place, that the losses in just a few months will exceed the cost of expert design. The use of manganese steel for buckets and other parts subject to abrasion and the use of chrome-nickel steels for parts subject to great strains are notable. Many dredges have been built of second-hand parts, and in a large number of these cases, the cost has exceeded the cost of a new dredge.

Pontoon-Hulls.

Bucket-ladder dredges were built with hulls of steel pontoons of a size suitable for easy transportation long before that design was adopted for dragline dredges. The first of these was No. 96 of Yuba Manufacturing Co. built originally in Montana in 1933. It was later dismantled and shipped in 19 days, and then re-assembled in California in 38 days. The crew was about the same size as that required for regular dredge operation on three shifts. In moving the dredge they all worked on one shift. The hull of this dredge is 90 ft. 6 inches long by 37 ft. 4½ inches wide by 8 ft. 1 inch deep. Buckets are of 6-cu.-ft. capacity and the dredge digs 150,000 cubic yards per month to a depth

[1] Janin, Charles, Gold Dredging in the United States: U. S. Bur. Mines Bull. 127, 1918. (Out of print.)

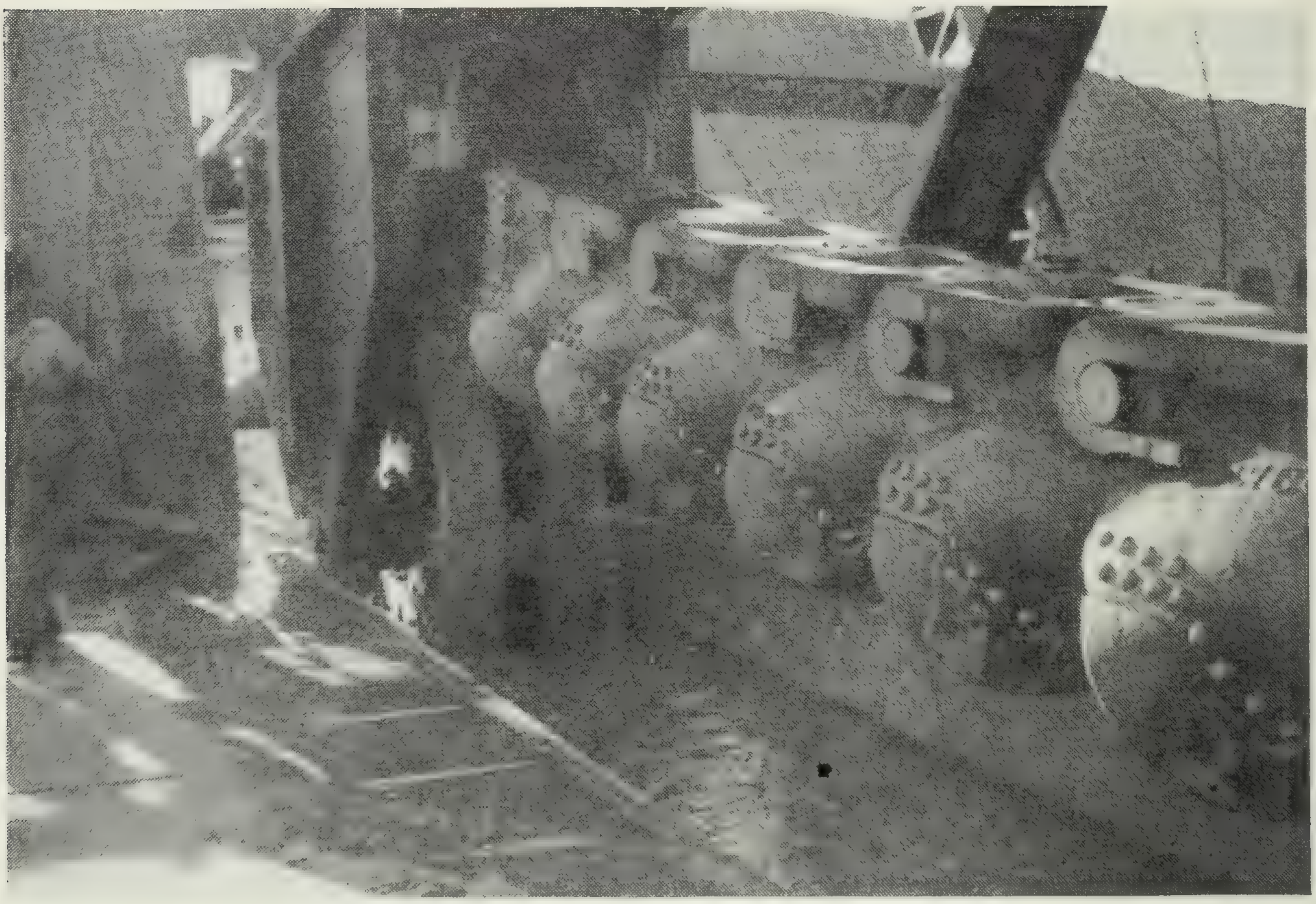


Photo by Walter W. Bradley

PHOTOGRAPH 6a. Perry idler on Yuba No. 17 dredge.

of 26 ft. in gravel of an ordinary degree of compaction. Pontoons are practically cubic in shape and all of the same size. Later dredges have been designed in such a way that partitions are more favorably placed to strengthen the hull. In this design pontoons are of various sizes and shapes. The dredge of Junction City Mining Co., built by Yuba Manufacturing Co., and the dredge of Yreka Gold Dredging Co., built by the Walter W. Johnson Co., are of this general type. Further details on these two dredges are given under the above headings arranged alphabetically on later pages. Yuba Manufacturing Co. has built 12 or more dredges of this type, and their experience is that when the pontoons are properly designed and arranged a hull built of pontoons is equal in strength and service to the more common type of hull braced with structural steel. These multiple compartments in a pontoon-hull afford a great protection against sinking.

New Bucket-Designs.

Buckets of new designs are now in use in which the replaceable wearing-edge of the lip is held by only two bolts instead of the large number of rivets formerly used. The lips can be changed quickly and lost time from this source is reduced. Such buckets are made by Taylor-Wharton Iron & Steel Co., Balfour Building, San Francisco, and by American Manganese Steel Co., 956 Ferry Street, Oakland.

Perry Idler.

In 1933, Yuba Manufacturing Co.[1] rebuilt dredge No. 17 at Hammonton to dig to a depth of 150 ft. The rebuilt all-steel hull is 233 ft.

[1] Romanowitz, C. M., and Young, G. J., $35 Gold stimulates the dredge designer's ingenuity: Eng. and Min. Jour., vol. 135, pp. 338-341, 1934.

9 inches long by 68 ft. wide by 11 ft. 6 inches deep. The total weight of the entire dredge is 3220 tons. The digging system weighs 740 tons, of which the ladder weighs 315 tons. It is 200 ft. in length between tumbler centers. The bucket line comprises 126 buckets, each of 18 cu. ft. capacity. To help support this great weight a Perry idler was installed on the under side of the bucket-line near the midpoint of the ladder, to divide the catenary into two parts. The idler is 10 ft. in diameter and weighs 40 tons.

Digging-depth below water line for No. 17 is 112 ft., the balance of the depth being carried as bank. At about the same time, in 1934, that No. 17 started, Yuba [1] No. 18, another 18-cu. ft. dredge, was equipped with a new bucket line but no idler. It digs to a depth of 81 ft. below water level, and performs in about the same way as a number of other Yuba dredges of the same size. A comparison of these dredges, made in 1935, shows that on No. 17 the heel plates on the upper tumbler have a life 2 to 2.4 times the life of the same parts on No. 18. The bucket pins and bushings on No. 17 last 1.8 times as long as those on No. 18. The idler showed practically no wear. Hence engineers of Yuba Manufacturing Co. believe that the installation of this idler would be economical on all dredges digging to a depth of 60 ft. or more.

Jigs.

The use of jigs on dredges has recently been described by P. Malozemoff,[2] Metallurgical Engineer, Pan-American Engineering Corporation, Berkeley, California. Jigs are being used by Bulolo Gold Dredging Company in New Guinea, and by several dredges in Colombia. A number of experiments have been made with jigs on dredges in California, starting in 1914, but they are not yet used to any extent. Yuba

PHOTOGRAPH 7. A. C. Mining Co. dredge under construction.

[1] Romanowitz, C. M., New digging-ladder bucket idler: Eng. and Min. Jour., vol. 137, p. 49, 1936.

[2] Malozemoff, P., Jigging applied to gold dredging: Eng. and Min. Jour., vol. 138, No. 9, pp. 34-37, 1937.

dredge No. 19 at Hammonton is now being operated entirely with jigs as an experiment. No riffles are used. Dredges in northern California, described in this article, all use riffles.

DREDGES OPERATING IN SHASTA, SISKIYOU AND TRINITY COUNTIES

A. C. Mining Co. (Collins), 1617 S. W. 19th Avenue, Portland, Oregon, operated a dragline dredge during the early part of 1937 in Sec. 2, T. 32 N., R. 5 W., at Buckeye, seven miles north of Redding. The location is the same as that mined first by Pioneer Dredging Co. for a period of a few months. Water is available during winter and spring only, and no dredging has been done during the dry season.

The washing plant is built on a barge of steel-pontoon construction, 48 ft. by 32 ft., made in Redding by Gerlinger Foundry and Machine Works, Inc. The tailing stacker is shorter than those commonly used, and is supplemented by a sand-pump with 8-inch discharge pipe mounted above the belt-stacker.

Baker Dry-Land Dredge. M. D. Baker of Redding has recently completed the installation of a 'dry-land dredge' in Sec. 34, T. 32 N., R. 6 W., on Clear Creek four miles southwest of the old town of Shasta. Gravel is mined with a P. & H. gasoline shovel of the dipper-stick type with bucket of one cubic yard capacity. The washing-plant is of timber construction built on heavy timber skids, and is designed to be pulled by a cable attached to the shovel. It consists of a hopper at a low elevation into which gravel is dumped by the shovel. From the hopper the gravel is raised to a trommel at a higher elevation by a belt conveyor. Oversize is stacked by a second belt conveyor, and undersize is washed in riffle sluices. Sands are discharged by a sluice mounted on trestles resting on the ground. One gasoline engine drives the first belt-conveyor and the trommel; a second gasoline engine drives the stacker; while water is pumped from Clear Creek with a third gasoline engine (Hudson automobile). Some damage was done to the equipment by high water in Clear Creek in December, 1937. This same outfit was in operation near Igo for a short time.

Cal-Oro Dredging Co., L. Gardella, 681 Market Street, San Francisco, has operated a bucket-ladder dredge with 6-cu. ft. buckets from time to time in Sec. 27, T. 45 N., R. 7 W., just south of Yreka. It has been idle recently, but reports indicate that a new tract of land has been acquired for further operation.

Carlson & Sandburg, L. D. Carlson and John Sandburg of Redding, operated three dragline outfits including a 3-cu. yd. electric on land between Sec. 23 and Sec. 31, T. 31 N., R. 5 W., five miles southwest of Redding, during 1937. This land is on the Olney Creek and the Clear Creek drainages. On the latter, some stripping of overburden was done with a Caterpillar tractor and a Le Tourneau carryall. Late in 1937, one of the outfits was moved to Indian Creek, Sec. 5, T. 32 N., R. 9 W., in Trinity County near Douglas City. Another was moved to Sulphur Creek just north of Redding, Sec. 23, T. 32 N., R. 5 W. Washing plants are of Bodinson make.

Cascade Dredging Co., a limited partnership of B. M. Stites, Cottonwood, and others, operated a dragline dredge during a part of 1937

in Sec. 7, T. 29 N., R. 5 W., 10 miles west of Cottonwood. The work was done along Cottonwood Creek and up a small tributary to a point close to the Cottonwood-Gas Point road, in an area a quarter of a mile in length, 250 ft. in width, and to a depth of 5 ft. to 15 ft. A compact clay bedrock caused some difficulty in digging. Both gold and platinum were produced.

A dragline shovel with a 1¼-cu. yd. bucket was used, and a washing plant built on a wooden barge. Diesel engines furnished the power. The outfit was idle in the fall of 1937.

El Oro Dredging Co., a California corporation, Verne H. Carter, Managing Director, Cottonwood, operated a dragline dredge during part of 1937 in Sec. 3 (?), T. 29 N., R. 5 W., nine miles west of Cottonwood. The company leased 158 acres of land on a tributary of Dry Creek east of the main stream. A Northwest dragline shovel with a

PHOTOGRAPH 8. Carlson and Sandburg dragline dredge for 3-cubic yard shovel. (Photo by courtesy Bodinson Mfg. Co.)

1½-cu. yd. bucket was used and a washing plant on a wooden barge equipped with Bodinson machinery. A Caterpillar gasoline tractor of 50 hp. with bulldozer attachment was used for clearing the land and leveling ahead of the shovel. Including the manager, a crew of 12 men operated the machinery for 24 hours per day. In addition to gold, some platinum-group metal was sold, containing roughly 35% iridium, and netting the company $55 per ounce according to Carter. The outfit was idle late in 1937, and apparently was to be moved to a new tract of land.

Gold Acres Dredging Co., controlled by P. G. Flummerfelt and Miss Helen Ardelle, 658 Haddon Road, Oakland, California, is operating a dragline dredge in Sec. 2, T. 29 N., R. 6 W., 14 miles west of Cottonwood. The shovel is of 1½-cu. yd. size and the washing plant is on a wooden barge, 30 ft. by 40 ft. Diesel engines furnish the power. Brush and oak and pine timber are cleared from the land ahead of the dredge with a Caterpillar tractor.

The property contains 400 acres and 30 acres of it have recently been dredged just south of the Cottonwood-Gas Point road. The outfit moves back and forth taking a cut 90 ft. wide each time. Depth is 6 ft. to 12 ft., and bedrock is volcanic tuff. The land is a flat roughly 25 ft. higher than Cottonwood Creek, and probably contains an upper terrace of this creek. Water is pumped from the creek with a Caterpillar diesel engine. Some platinum is produced as a byproduct.

Gold Bar Dredging Co. See Lewiston Gold Dredging Co.

Hayfork Gold Dredging Co., Charles C. Stearns, Manager, Hayfork, California, is operating a dragline dredge in the channel and on the benches of the Hay Fork of Trinity River, just outside of the town of Hayfork, in Sec. 11, T. 31 N., R. 12 W. The property contains 260 acres of dredgable land leased from Van B. Young, Emma C. Young, George English, Dan Gordon and others.

The channel of the Hay Fork of Trinity River has recently been dredged for a width of 150 ft. and a depth of 10 ft. This present channel runs west, while the channels on the benches run north and south, and hence must belong to an earlier system of drainage. Bedrock is soft and dark green in color, and has the appearance of serpentine. It is probably derived from a basic lava or tuff of Tertiary age. Wells are said to have been driven through it into gravel lying beneath. No gold or platinum are found more than two feet above bedrock, and as much as two feet of the bedrock are taken up by the shovel to recover gold and platinum in the crevices. Top soil is stripped to a depth of several feet with a No. 75 Caterpillar tractor (Diesel) and a Le Tourneau carryall. One of 8-cu. yd. capacity has been in use, and cost of stripping has been 3 cents per cubic yard. A 12-cu.-yd. carryall has recently been substituted, and is expected to reduce this cost to 2 cents per cubic yard.

Excavating is done with a 1½-cu. yd. Lima dragline shovel with a 45-ft. boom, which will reach to a depth of 15 ft. The side-cut method is in use, in which the shovel travels back and forth at a right angle to the channel. This allows the bucket to travel parallel to the channel in all parts of the cut, and the bedrock is said to be cleaned much better than when the shovel travels along the channel and reaches to the sides with the boom. A wooden barge carries the usual hopper, trommel, riffle-tables and stacker. Diesel engines furnish the power. Some large boulders are found in the gravel, and they are laid aside by the shovel whenever possible to avoid handling them on the barge.

The equipment is kept in operation 24 hours per day by a crew of 17 men. The capacity varies from 1500 cu. yd. to 2500 cu. yd. per day. The lower capacity is usually caused by an excess of sand in the riffle-sluices. Actual digging time is said to average 19 hours per day. According to Stearns, when 2500 cu. yd. are handled per day, the cost per yard is 7 cents including 1½ cents per yard for depreciation. This is for the gravel handled by the shovel; stripping is not included. The machinery was originally installed by Wyandotte Dredging Co., and was bought from that company. Stearns states that the total investment is $50,000. When work is done on the benches, water is pumped from the creek with a 100-h.p. diesel engine at a

cost of $300 per month. Enough platinum (35% iridum) is produced to pay the wages of all shovel-operators.

Junction City Mining Co. started a modern steel bucket-ladder dredge in Sec. 18 and adjoining sections, T. 33 N., R. 10 W., near Junction City, on January 10, 1936, and has been operating continuously since. Harvey Sorensen, 685 6th Street, San Francisco, is president; C. M. Derby, Mills Tower, San Francisco, is consulting engineer; and L. T. Roberts is superintendent at Junction City. Some of the machinery from the old Madrona dredge was used.

The hull is new and of the latest pontoon design, being No. 113 of Yuba Manufacturing Co. Transportation over mountain roads was one reason for adopting this design. The hull is 120 ft. by 52 ft. by 8 ft. 1 inch deep, and is made of 31 pontoons. These are designed and

PHOTOGRAPH 9. Dredge of Junction City Mining Co.

arranged so that the inside walls strengthen the hull at critical points. The largest pontoon weighs 24,000 lb. and the smallest 4800 lb. Most of them weigh from 10,000 lb. to 16,000 lb. When assembled they form a rigid structure due to the beam-effect of the side-walls.

The bucket-chain contains 79 buckets of 9½-cu.-ft. capacity each, and the dredge is capable of digging to a depth of 45 ft. below water-line, although the actual depth of the gravel averages 30 ft. Bedrock varies from soft to hard but is decomposed enough so that a few inches can be taken up. The dredge is held in digging position by a single spud of 32 tons. The trommel is 7 ft. in diameter and is perforated with ⅜-inch to ½-inch holes, but one section of 2-inch mesh is provided for recovery of nuggets. Riffles are of the Hungarian dredge type described in the general section on dragline dredging, and are shod on top with ⅛-inch strap iron. The stacker for coarse tailing is 135

ft. long and carries a 36-inch belt. The operating crew averages 24 men.

Electric motors are as follows: 50 hp. on a high-pressure 10-inch pump, 50 hp. on a low-pressure 10-inch pump, 50 hp. on an auxiliary 10-inch pump, 25 hp. on a 4-inch pump, 35 hp. on the winch, 35 hp. on the screen, 50 hp. on the stacker, and a 200-hp. digging motor.

The following figures on operation are furnished through the courtesy of C. M. Derby, consulting engineer. For the fiscal year ending in June, 1937, the operating cost under rather severe conditions averaged 4.98 cents per cubic yard. This includes labor, materials, power, ordinary taxes, and general expense. No land-cost, no royalty and no depreciation are included. The average monthly yardage was 240,000 cu. yd. The approximate cost of the dredge was $250,000.

Lewiston Gold Dredging Co. is a new company formed to take over the Gold Bar dredge at Lewiston. It should not be confused with Lewiston[1] Dredging Co., which formerly operated a dredge farther up Trinity River at Minersville. The new company is a partnership of 13 persons, of whom three are general partners, Elwyn W. Stebbins, F. J. Estep, and C. H. Thurman, Manager, 420 Market Street, San Francisco. W. J. Harvey is superintendent at Lewiston.

The location is Sec. 18, 19, T. 33 N., R. 8 W. The present operators started in June, 1937, and expect to work from Lewiston down the river for two miles. Their work is on an upper terrace. A new revolving screen and other new parts have been installed on the dredge, and steel pontoons for extending the hull have been delivered.

The Gold Bar dredge was described in State Mineralogist's Report XXIX. The hull is 79 ft. by 44 ft. by 7 ft., and it carries a chain of 45 buckets of 8 cu. ft. capacity each, digging to a depth of 31 ft. below water line. It is held in position by headlines of 1½-inch steel cable. No spuds are used. Electric motors are as follows: 150-hp. digging motor, 30 hp. on 8-inch pump, 50 hp. on 10-inch pressure pump, 40 hp. on seven-drum winch.

Midland Company, a California corporation, 4th and Dwight Way, Berkeley, California, has been operating a dragline dredge in Sec. 4, T. 29 N., R. 5 W., 10 miles west of Cottonwood. Dry Creek has been dredged from its confluence with Cottonwood Creek for a distance of nearly two miles to a width of several hundred feet and a depth of 7½ ft. F. A. Hoyer was superintendent at Cottonwood, and Ben Howard was dredge-master. In January, 1938, this property had been worked out, and the outfit was to be moved to a new location near Red Bluff.

The shovel is a 1¼-cu. yd. Thew-Lorain dragline powered with a 109-hp. Caterpillar Diesel engine. The washing plant is on a wooden barge 30 ft. by 40 ft. by 36 inches, covered with 3-inch planks. From the hopper the gravel goes to a revolving screen 30 ft. by 4 ft. made by Thew-Lorain. Holes are ⅜-inch and the metal between varies from 1 inch to ⅜-inch in the six sections. The riffle system has an area of 552 square feet, and a combination of expanded metal lath over

[1] Averill, C. V., Gold deposits of the Redding and Weaverville quadrangles, Lewiston Dredge: Calif. State Mineralogist's Report XXIX,, pp. 65-66, 1933. Requa, L. K., Description of the property and operations at the Lewiston dredge, Lewiston, Calif.: U. S. Bureau Mines Inf. Circ. 6660, pp. 1-15, 1932.

burlap and dredge-type Hungarian riffles is used as described in more detail in the general section on riffles above. Water is pumped from the pond with a Fairbanks-Morse pump of a capacity of 4000 gallons per minute when running at 1200 rpm. Power on the barge is furnished by an 85-hp. Fairbanks-Morse Diesel engine. Two eight-hour shifts were worked per day with a total crew of 10 men, and cleanups were made between regular shifts.

Olson Dredge. Roy S. Olson of Redding dredged 100 acres of gravel along China Gulch in 1937. The location is Sec. 36, T. 31 N., R. 5 W. and adjoining sections, five miles south of Redding. Bedrock is a volcanic tuff apparently laid down in water. The 1½-cu. yd. dragline outfit was later sold to Pioneer Dredging Co.

PHOTOGRAPH 10. Dragline dredge of Midland Co.

Oro Trinity Dredger Co. controlled by R. G. Stapleton and C. E. Cummings of Oroville installed a 1½-cu. yd. dragline outfit on the Arbuckle property at Weaverville, Trinity Co., late in 1937. D. A. McQueen is manager.

Pioneer Dredging Co. started as a partnership of four persons, but is now owned by R. W. Baker, Box 700, Redding, California. Three dragline dredges are operated including a 3-cu. yd. electric. The first was installed at Buckeye, Sec. 2, T. 32 N., R. 5 W., where water is available during winter and spring only. After one season's operation here, it was moved to Dry Creek near Igo. The three dredges are now operating near Igo and Olinda, about 15 miles southwest of Redding, Sec. 11, 18, 19, 28, 29, 32, 33, T. 30 N., R. 5 W.

PHOTOGRAPH 11. Dragline dredge of Pioneer Dredging Co.

On Dry Creek, where 2880 acres of patented land are held, the channel and first terraces will be dredged for a length of 4 miles, width of 1000 ft., and depth of 5 ft. to 10 ft. On Spanish Gulch, where 195 acres are held, the channel will be dredged for a length of 4 miles, width of 400 ft. and depth of 3 ft. to 9 ft. On Spring Gulch, where 75 acres are held, the entire area will be dredged to a depth of 3 ft. to 9 ft. Shovels are all of Lima make, and washing plants are Bodinson. Bedrock is volcanic tuff.

Roaring River Gold Dredging Co. is dredging on Roaring River, a tributary of Cottonwood Creek, in Sec. 4, 5, T. 29 N., R. 6 W., 15 miles west of Cottonwood, with a new dredge of the bucket-ladder type. Norman Cleaveland, 351 California Street, San Francisco, is manager, and J. Ellery Sanders, Cottonwood, California, is superintendent. The company controls two miles along the channel, which will be dredged to an average width of about 800 ft. and depth of 10 ft.

The dredge is of the steel pontoon type with hull 75 ft. by 36 ft. by 6 ft. deep and draft of 4 ft. Machinery was built by Joshua Hendy Iron Works, San Francisco. A single spud of roughly 10 tons is provided to hold the dredge in digging position. The rated capacity is 60,000 cubic yards per month, but the actual capacity has been greater, reaching as much as 2700 cu. yd. per day when bucket-line speed is 36 buckets per minute. It is operated 24 hours per day with a crew of 18 men including those clearing land and tending pump.

From the bucket-line, which carries 72 buckets of 3 cu. ft. capacity each, gravel is dumped into a trommel-screen $4\frac{1}{2}$ ft. in diameter by 23 ft. long, where it is washed with water discharged from nozzles. Oversize goes to a 56-ft. tailing-stacker, on which runs a 24-inch belt. The trommel-screen contains four drilled and countersunk high-carbon steel or cast manganese steel sections, each 4 ft. in length, one section

with $\frac{1}{4}$-inch to $\frac{3}{8}$-inch holes, two sections with $\frac{3}{8}$-inch to $\frac{1}{2}$-inch holes, and one section with $\frac{1}{2}$-inch to $\frac{5}{8}$-inch holes. Sand and water passing through the screen drop to the usual riffle-sluices running crosswise of the boat, thence to sluices running lengthwise of the boat, which discharge on both sides of the stacker at the stern. Riffles are of the standard Hungarian type used on dredges (see above). Instead of being shod on top with the usual strap-iron, they are shod with rubber strips $1\frac{1}{4}$-inches wide and $\frac{3}{16}$-inch thick, supplied by American Rubber Manufacturing Co., Oakland, California. They are said to wear better than iron. Quicksilver is used in these riffles; also in some solid rubber blocks in which shallow grooves are cut parallel to the riffles. The shallow grooves hold the quicksilver close to the lower surface of the sand and water flowing over them, so that particles of gold are amalgamated. Wooden riffles are beveled for about $\frac{1}{4}$-inch on the upper edge so that the rubber top has a slope opposite to that of the sluice. This together with the excess width of rubber over that of the wood beneath tends to cause turbulence in the space between riffles.

Power on the dredge is furnished by two D-13000 Caterpillar Diesel engines, which are rated at 95 hp. each on sustained load or 130 hp. maximum. One of these drives the bucket-line, the winch for swinging the dredge, and the trommel-screen. The other drives the two pumps, the stacker, and the welding and lighting equipment. A Ford V-8 engine is provided as a stand-by for lights. The two Byron Jackson 8-inch pumps of the dredge type on the boat operate against 40-ft. and 60-ft. heads of water respectively. During the summer a supply of water for the dredge-pond is pumped from the Middle Fork of Cottonwood Creek with a 5-inch pump driven by a 40-hp. Caterpillar Diesel engine. This water is pumped over the ridge

PHOTOGRAPH 12. Roaring River Gold Dredging Co.

between the two streams through a quarter mile of 8-inch pipe against a head of 100 ft.

Each of the large engines burns $4\frac{1}{2}$ gallons of oil per hour, while the smaller pumping engine burns $2\frac{1}{2}$ gallons per hour. Consumption of lubricating oil amounts to 200 gal. per month. Fuel-oil costs $7\frac{1}{2}$ cents per gallon and lubricating oil costs 52 cents per gallon delivered at the dredge.

This dredge recovers platinum-group metals as well as gold, the proportion of platinum-group metals being one of the highest for Californian dredges. The ratio of gold to platinum-group metals varies roughly between 20 to 1 and 30 to 1.

Savage & Dodson, Red Bluff, California, have recently made some repairs to the *Gas Point Dredge* formerly owned by *Ogden & Wilson* in Sec. 3, T. 29 N., R. 6 W. on Roaring River, near Gas Point, which is 15 miles west of Cottonwood. The land is leased from Trautz and Green, Cottonwood. They plan to dredge 21 acres on Crow Creek, a tributary of Roaring River.

A new trommel, 4 ft. by 20 ft., with $\frac{3}{8}$-inch holes, new 70-ft. stacker with a 24-inch belt, a new 10-inch pump have been installed. The wooden hull of the dredge is 80 ft. by 30 ft by 6 ft. Power is furnished by a 70-hp. oil-engine, burning stove oil. Buckets are of 3-cu. ft. capacity.

Bibl: State Mineralogist's Report XXIX, p. 61.

Trinity Dredging Company has operated a dredge for many years in Sec. 5, 6, 7, and others, T. 33 and 34 N., R. 8 W., four miles north of Lewiston, Trinity County. Miss Mary Smith of Lewiston is president and Chas. R. Harris is dredge master. The bucket-line of this dredge carries 42 buckets of 11-cu. ft. capacity and 42 links of the same length as a bucket. When the bucket-line is heavily loaded, these links carry about 2 cu. ft. each. Nine buckets are dumped per minute. Gravel is washed in a trommel with 6-inch and 8-inch holes. Oversize, up to 4 ft. in diameter, is dumped over the side through chutes. Undersize goes through the holes in the trommel to a sluice 125 ft. long, 4 ft. wide and 2 ft. deep. The lower part of the sluice, 110 ft. long, is carried on a scow behind the dredge. Separate drums are provided on the winch to swing the sluice for proper distribution of tailing, which is deposited so that the surface is left nearly level. Riffles are made of 2-inch by 3-inch steel angles with 2-inch face up and 3-inch face vertical. Spacing between angles is 2 inches. The tops are protected with manganese-steel castings, one inch thick, made with bars two inches wide alternating with two-inch openings. The castings are in sections 4 ft. square. Some of these assembled riffle sections, 4 ft. square, are placed with the bars lengthwise of the sluice, but most of them are placed crosswise. The hull of the dredge is 110 ft. long, 50 ft. wide and 7 ft. deep, and draws about $5\frac{1}{2}$ ft. of water. It is provided with two steel spuds of 25 tons each.

List of motors, all taking power from lines of the Pacific Gas and Electric Co. at 2200 volts, follows: 150-hp. digging motor geared to line with herringbone gears, no belt; 52-hp. winch motor driving 10-drum winch; 100-hp. on 16-inch centrifugal pump; 35 hp. on 6-inch centrifugal pump; 25-hp. on trommel; 25-hp. on compressor and other

shop tools; 50-hp. on shore pump needed at times to keep the pond full of water.

Bibl: State Mineralogist's Reports XIV, p. 919; XVIII, pp. 601, 734-35; XXII, pp. 59, 62; Prelim Rep. No. 8, p. 18; Bull. 36, p. 104; Bull. 92, p. 95; XXIX, pp. 70-71. U. S. G. S. Bull. 540, p. 20.

Viking Dredging Co. was incorporated late in 1937 by Irving N. Benson, David W. Hinds, Carl V. Needham, all of Redding; and E. B. Noble of Red Bluff. A dragline dredge was to be installed at the confluence of Redding Creek and Trinity River, Sec. 12, T. 32 N., R. 10 W., near Douglas City.

Weaver Dredging Co., R. C. Dempster, Redding, and Oscar R. Batham, Weaverville, is mining a part of Weaver Creek just above Douglas City, Sec. 1, T. 32 N., R. 10 W. A dragline shovel of 2½-cu. yd. size is used and a Bodinson washing plant with diesel power. The main channel of Weaver Creek was worked by early-day placer miners by hand. Later considerable tailing from hydraulic mines was deposited in the channel. This material is being reworked by the dragline dredge together with some virgin bars along the sides. Bedrock is schist, and varies from a soft, decomposed variety to hard rock that stands up in ribs, adding to the difficulty of digging.

Wyandotte Gold Dredging Company, which pioneered dragline dredging in the Oroville district, Butte County, also built the first outfit to serve an electric shovel with a 3-cu. yd. bucket in the Redding district. The washing plant was of Bodinson make built on steel pontoons. It was installed on Churn Creek near Enterprise, Sec. 17, T. 31 N., R. 4 W. Operations were conducted here for only a short time, then the outfit was sold to Carlson & Sandburg, who moved it to Clear Creek, Sec. 31, T. 31 N., R. 5 W. Persons associated with Wyandotte also installed the outfit now operated by Hayfork Gold Dredging Company.

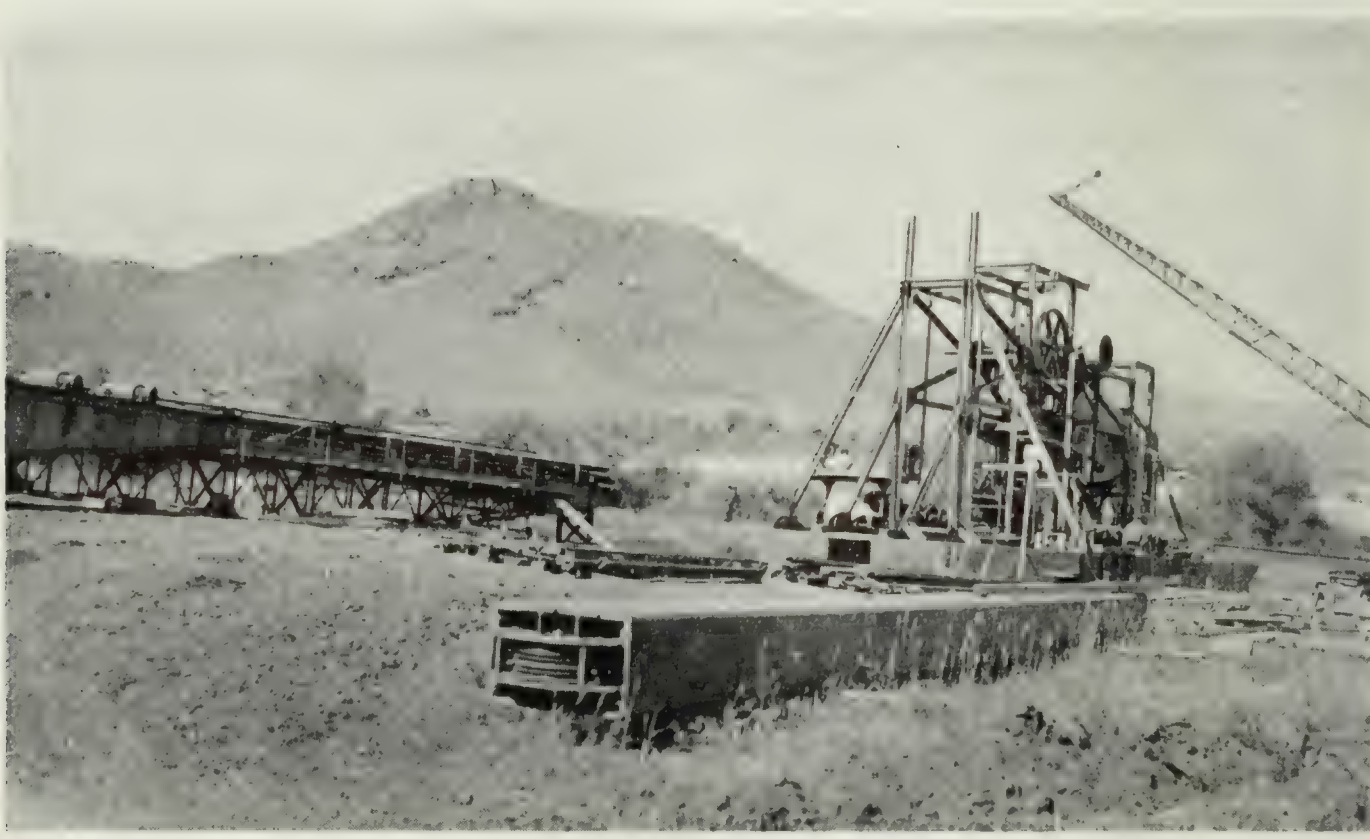
Bibl: State Mineralogist's Report XXXII, pp. 374-375.

Yreka Gold Dredging Company built a new dredge in 1937 to work in Sec. 14, T. 45 N., R. 7 W., and adjoining sections along two miles of Yreka Creek just north of Yreka. Ethredge Walker is president and Albert Schubach is secretary, Balfour Building, San Francisco. Eric Peterson is dredge-master at Yreka. The dredge was built by Walter W. Johnson Co., Balfour Building, San Francisco, and the following details are furnished through the courtesy of that company.

The hull is approximately 82 ft. by 42 ft. by 7 ft., and is made of 19 pontoons about 20 ft. by 10 ft. by 7 ft., weighing 6 tons to 7 tons each. Exposed walls are made of $\frac{9}{16}$-inch steel and inside walls adjacent to other pontoons are of $\frac{3}{16}$-inch steel. The pontoons and all structural parts, the digging and stacking ladders, frame for revolving screen, distributors, and 10-ton spud are of electric-welded construction, which has proved very satisfactory.

The bucket-line carries buckets of 6 cu. ft. capacity each, to dig to a depth of 25 ft. Buckets are of the new rivetless-lip, bowl-shaped design, and are made of manganese steel by American Manganese Steel Co., Oakland. Lower tumbler is made of manganese steel and

PHOTOGRAPH 13. Steel hull of dredge of Yreka Gold Dredging Co.



PHOTOGRAPH 14. Dredge under construction. Yreka Gold Dredging Co.

is round; upper tumbler is of high-carbon steel, six-sided, and cast integral with shaft. The hopper-chute is lined with manganese steel bars. A special feature of this is a removable back plate for discharging boulders too large for the revolving screen. The boulders are dumped, without stopping the bucket-line, on a fork made of heavy bars. These are swung by a heavy shaft operated by a compressed-air cylinder to dump the boulder into a steel-lined chute which discharges into the pond. Dumping is regulated by a gate in the chute, so that the boulder can be placed in some part of the pond where it will be out of the way.

The revolving screen is 34 ft. long by 6 ft. in diameter, and is lined with manganese steel plates. Perforations are $\frac{3}{8}$-inch to $\frac{1}{2}$-inch and $\frac{5}{8}$-inch to $\frac{3}{4}$-inch in the sections of screen except the last, which has $\frac{3}{4}$-inch by $\frac{1}{2}$-inch slots for recovery of nuggets. Several feet at each end of the screen are not perforated. Undersize from the screen is treated on 1600 sq. ft. of riffle-tables. Riffles are of angle-iron, $1\frac{3}{16}$ inches by $1\frac{3}{16}$ inches spaced at 1 inch; also of wood, some shod with steel, some with rubber. They are $1\frac{3}{16}$ inches deep spaced at 1 inch. Oversize from the screen is stacked by a stacker 90 ft. long carrying a 36-inch American Rubber Co. rib-stacker belt.

Water is pumped from the pond by Byron Jackson pumps of 82% efficiency. The 10-inch high-pressure pump furnishes 3200 gallons per minute at 65-ft. head to the revolving screen. The 8-inch low-pressure pump furnishes 1800 gpm. to the riffle-tables. A 4-inch pump is provided for cleanups, washing decks, and fire-protection.

The winch is a combination ladder-hoist, swing-line and spud-line winch controlled entirely by compressed air. This method of control adds to the efficiency of the dredge. A two-speed, specially designed motor delivers 55 hp. at 1200 rpm. or 35 hp. at 600 rpm. At the higher speed, it provides ample power for raising the digging-ladder, raising the spud, and swinging the dredge when stepping ahead. The low speed is used for swinging during regular digging.

Other electric motors are as follows: 100-hp. variable-speed on the bucket-line, 60-hp. on the high-pressure pump, 15-hp. on the low-pressure pump, 40-hp. with reduction gearing on the revolving screen, 25-hp. with reduction gearing on the stacker, and 3-hp. on the fire-pump. Power is transmitted by the bucket-line and winch motors to the driven pulleys with multiple V-belt drives.

Power is taken on the dredge at 2400 volts and is stepped down by three 100-kva. transformers to 440 volts. A 5-kva. transformer is provided for lights.

The dredge is operated 24 hours per day by one dredge-master, three winchmen, three oilers, two shore-men, one tractor driver, and one cleanup man. The direct operating cost is 4.3 cents per cubic yard to which should be added $\frac{1}{2}$ cent per yard for management and shipment of bullion. No depreciation, no land-cost and no royalty are included. The capacity at Yreka is 140,000 cu. yd. to 150,000 cu. yd. per month. The same dredge would handle 210,000 cu. yd. in easier ground. It cost approximately $160,000 including some miscellaneous pumping equipment for pumping muddy water out of the pond, but not including the 55-hp. Caterpillar tractor with diesel engine and bulldozer.

PHOTOGRAPH 15. Yuba Consolidated Gold Fields, Callahan, Siskiyou County.

Yuba Consolidated Gold Fields built a new dredge near Callahan, Siskiyou County, in 1936, in Sec. 8, T. 40 N., R. 8 W. From a point near the confluence of Wildcat Creek and Scott River, it will work for several miles up the river. F. C. Van Deinse, 351 California Street, San Francisco, is vice-president and general manager. H. C. Perring is field-superintendent.

The dredge is No. 116 of Yuba Manufacturing Co., and is built on a steel hull not of the pontoon type, 122 ft. 8 inches by 56 ft. by 10 ft. It will now dig to a depth of 35 ft. below water line, but is designed so that extensions can be put on both the hull and the digging-ladder; and it will then dig to a depth of 50 ft. or 60 ft. To cope with very difficult digging, this dredge was equipped with machinery of sizes ordinarily used on dredges with 18-cu. ft. buckets, while its buckets are of 9-cu. ft. size. Concentric ladder suspension is used, that is the ladder and the bucket-chain turn on the same axis.

Gravel is screened in a trommel 8 ft. in diameter by 48 ft. long, of which 34 ft. are perforated with ½-inch to ⅝-inch and ⅜-inch to ½-inch holes. It turns at 7 rpm. The trommel is lined with ¾-inch plates of "abrasion resisting steel," a high-carbon, high-manganese steel supplied by United States Steel Corporation. It costs more per pound than ordinary steels but less per cubic yard dredged. Undersize from the trommel is treated on 3500 square feet of riffle-tables in a double-deck arrangement. They are provided with wooden riffles shod with steel. For washing, 10,000 gallons per minute of water are pumped from the pond. The total connected load is 750 hp., which includes an extra-heavy digging motor about midway in size between those customarily used in 18-cu. ft. dredges and 9-cu. ft. dredges.

The dredge is operated for 24 hours per day by a total crew of 24 men including a man in the office. The actual capacity is 210,000 cu. yd. per month in ground that is hard to dig.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

NEW STATE GEOLOGIC MAP—METHOD OF MOUNTING

The new State Geologic Map of California is now being printed, and will soon be ready for distribution. The colored proof has already been received in the office of the Division of Mines, and has been inspected by many persons interested, all of whom seem highly pleased with results.

The map consists of six sheets arranged according to the accompanying diagram. Each sheet is about 32″ x 42″, and overlaps by a few inches its adjoining sheets. Although Sheet IV contains the complete master legend with explanations of the different patterns and symbols illustrating the geologic formations, a more condensed legend is repeated along the outside margin of each of the other separate sheets. In mounting the group, condensed marginal legends would be cut off.

The six sheets of the geologic map are so printed that they may be mounted all together as a wall map. When thus assembled, they form a map $6\frac{1}{2}'$ wide by $7\frac{1}{2}'$ long. To those who wish to mount the map in such a manner, the procedure followed recently by the Division of Mines is recommended:

A piece of smooth, inexpensive congoleum rug, large enough to accommodate the entire map, was mounted on a broad table made for the purpose, and waxed. Inexpensive, 81-inch sheeting was soaked in water overnight, then stretched tightly over this table top and tacked around the edge. Ordinary boiled paste such as that employed for wall-paper was applied to the cloth. To insure evenness and absence of lumps, the whole paste-covered, stretched cloth was scraped with a straight-edge. Before mounting the map, the six sheets were immersed in water for a few minutes. It was found advisable to mount Sheet II and V before adding Sheets I and IV, III and VI. Since the edges of the sheets overlap, the one overlapping was cut in such a manner that lettering and crowded drafting was avoided. Thus, where the paper was plain, a straight line was cut; but where the map was intricately colored, a curved line was cut and better registration was made of the upper sheet on the one underlying it. In pressing the map down to the cloth, a rubber roller or squeegee, such as used by photographers, was employed; although a dry soft cloth rubbed by hand would have been satisfactory. The drying of this mounted map required several days. The upper and lower edges of the map were fastened on sticks or rollers to hang on the wall. The roller was made by slipping the edge of the map between two half-round mouldings and nailing the two together.

For use in travel, it is recommended that the six sheets be cut, each into 16 rectangles, and each set pasted on cloth in the same manner as above described, excepting that a space of at least $\frac{1}{4}''$ should be left between the cut pieces. It is not advisable to assemble the whole map when mounting in this manner for field use. The map thus prepared may be folded so that the part in use is left exposed for reference.

Since the principal roads, both highways and by-ways, are shown on this geologic map in addition to the geologic formations, the traveler will find that the map, mounted-to-fold for field use will be his constant companion.

The geologic formations, which are shown in many varied colors and patterns grouped in some 80 units, are outlined in black and each outlined formation also contains a significant letter-symbol corresponding to that shown in the geologic legend. There is a more or less standardized system of colors and symbols used by the U. S. Geological Survey and other organizations in the publication of geologic maps, and the Geologic Map of California has digressed very little from those standards. In the margins of the map, which are quite ample in size, various explanatory and index maps are shown.

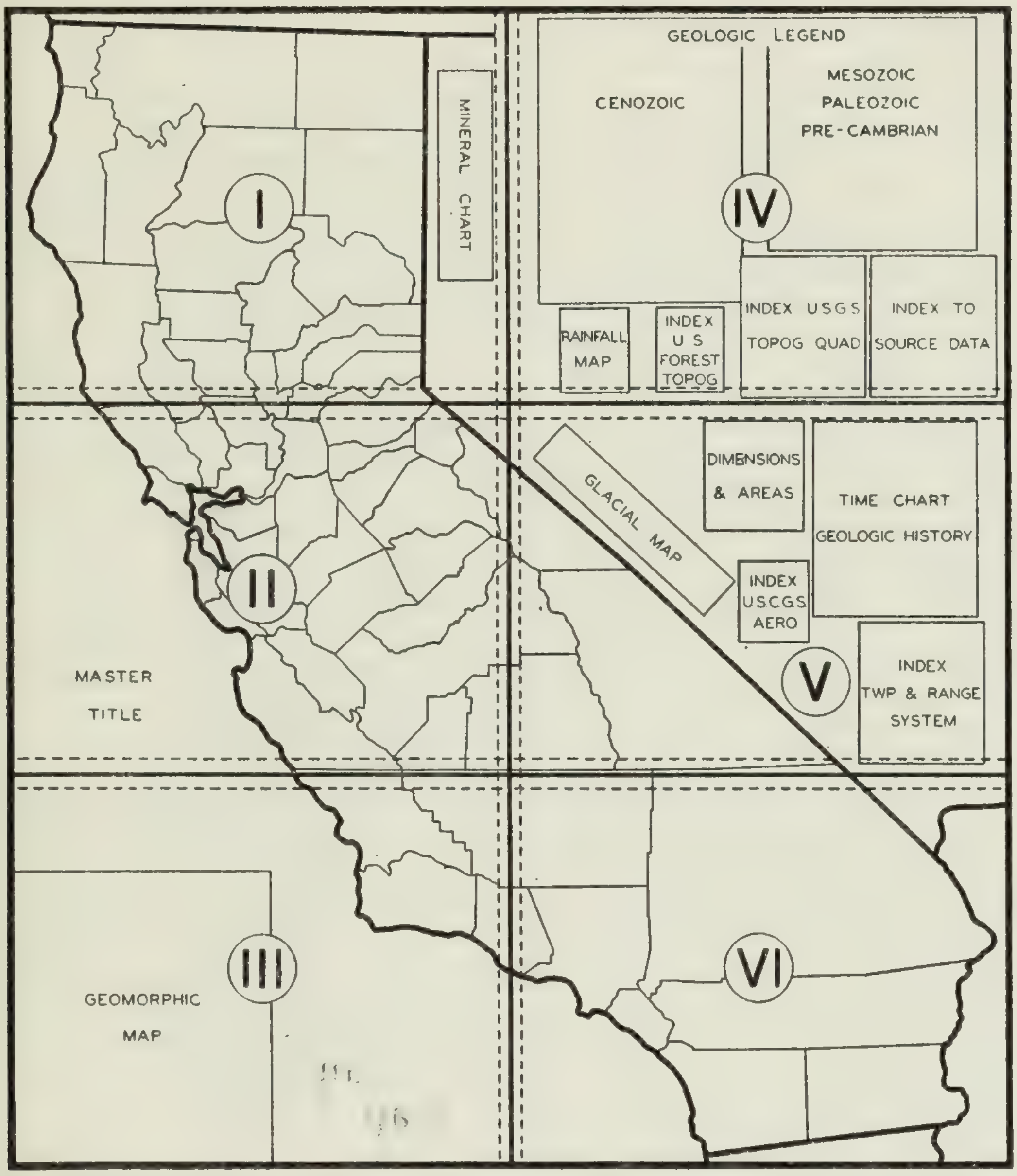
The index map showing the principal sources of geologic data with a list of names of contributors and an index to the areas they have mapped, is especially valuable as a guide to one who wishes to know the original source on which the compilation is based. Index maps to various topographic sheets, a chart showing mineral products of California by counties, a map showing the township and range system of California, another indicating the dimensions of the state and the size of its counties, all serve as useful guides.

In addition to these things, there is an outline map of the Sierra Nevada showing the distribution of the vanished Pleistocene glaciers. On Sheet III there is a Geomorphic Map, 20″ x 21″, which shows by brown contour lines the surface relief and by blue contour lines the submarine configuration; it is interesting to note that deeper canyons are to be found in the bottom of the sea than on the surface of the land.

The great earthquake fault lines which are shown in black on the body of the map are repeated in red on this little geomorphic map. Eleven major natural divisions or *geomorphic provinces* of the state are outlined by colored dotted lines. These provinces are: the Great Valley of California; the Sierra Nevada; the Cascade Range; the Modoc Plateau; the Klamath Mountains; the Coast Ranges; the Transverse Ranges; the Peninsular Ranges; the Colorado Desert; the Mojave Desert; and the Basin-Ranges. Descriptive material concerning each of these distinctive provinces is printed in the border of this geomorphic map.

Another chart which is placed on Sheet V is entitled "Looking Back in Geologic Time." It is a block diagram, drawn to indicate that one is looking far into the distance, as down a railroad track. The major geologic periods are scaled off in terms of hundreds of millions of years, but diminishing in the distance as by perspective. In this chart, opposite each geologic period, is briefly summarized the salient geologic events which are known from geologic evidence to have happened in California during that period.

The map not only serves as a guide to travel, but is in itself a condensed text to the geology of the state. It is by no means complete nor the last word in accuracy of detail, but it represents much careful study and hard work and should form a background for regional investigation and for further research.



Index to arrangement of the six sheets of the new Geologic Map of California.

Scale 1:500,000.

GEOLOGY OF THE CENTRAL SANTA MONICA MOUNTAINS, LOS ANGELES COUNTY

By E. K. Soper *

OUTLINE OF REPORT

ABSTRACT

The central part of the Santa Monica Mountains described herein lies just west of the area described in Professional Paper 165-C of the United States Geological Survey, and includes all of the Las Flores and Dry Canyon quadrangles, and the western part of the Topanga Canyon quadrangle. The topographic relief of this area is considerably higher than in the eastern half of the Santa Monica Mountains, although the

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highest points in the range are found still farther west. The elevations of the central area vary from about 1000 feet to about 3000 feet. Remnants of at least two well-marked elevated marine terraces occur along the coastal belt. The larger canyons on the south or seaward slope of the mountains show a steepening and narrowing of the lower canyon walls. This suggests fairly recent rejuvenation which possibly may be related to the terrace development.

The rock formations exposed in the area include the following: Chico and Martinez formations undivided (Upper Cretaceous and Paleocene) 4900-7500 feet thick; Sespe formation (non-marine; Eocene to lower Miocene), 1600-3275 feet thick; Vaqueros and Topanga formations undivided (lower and middle Miocene), 12000 ± feet thick; Modelo formation (upper Miocene), 4600 feet thick; Pleistocene terrace deposits (marine and non-marine), 25-50 feet thick; and Recent alluvium. The Topanga formation of middle Miocene age contains about 4000 feet of intrusive and extrusive basalt and volcanic breccia or agglomerate with some intercalated sandstone and shale beds. All pre-Topanga sediments contain numerous basalt dikes and intrusive sheets, and irregular intrusive masses. The post Topanga formations do not contain igneous rocks in this area. No Santa Monica slate or granite, so prominent in the eastern end of the Santa Monica Mountains, outcrops in the central or western parts of the range.

Fossils were collected in all formations except the Sespe. The best preserved and most numerous fossil fauna occur in the lower part of the Topanga formation. Although a careful search was made no vertebrate fossils were found in the non-marine Sespe beds.

A noteworthy feature of the stratigraphy of the western and central part of the Santa Monica Mountains is the rapid thinning eastward (shoreward) of the marine Vaqueros formation in marked contrast with the non-marine Sespe formation which becomes thinner toward the west, or basinward.

The anticlinal structure clearly apparent in the eastern part of the Santa Monica range becomes less evident in the central and western parts, where faulting, cross-folding, and igneous intrusions and extrusions have largely obscured all evidence of a major fold. The structure in the central area is essentially a north-dipping monocline upon which a north-plunging anticline and two north-plunging synclines have been superimposed. The apparent monoclinal structure of the central part of the range may represent the north flank of the westward continuation of the large anticline which forms the eastern end of the range, the axial line of which may be submerged beneath the Pacific Ocean toward the west. Along the coast an important east-west trending fault (Malibu Coast fault) separates the older formations on the north from a down-dropped block of Modelo formation on the south. This feature suggests that the central and western parts of the Santa Monica Mountains may represent only the north flank of an intricately faulted and invaded anticlinal structure, the faulted axis of which is now submerged off-shore. There is some evidence that the Modelo formation once covered the entire area, although only remnants now remain.

The earliest deformation of which there is a definite record in the central part of the range occurred in pre-Topanga time, and is represented by the total absence of any marine Eocene and Oligocene strata. In post-Topanga and pre-Modelo time the area was again affected by

important diastrophic deformations recorded in the sharp angular unconformity between the Topanga and Modelo formations. This deformation was preceded or accompanied by a sequence of basalt flows on the sea floor, and also by much faulting of the Topanga and pre-Topanga formations. In post-Miocene time and again in post Pliocene time the area was affected by folding, faulting, and uplift. These disturbances continued intermittently until late Pleistocene time as evidenced by the elevated wave-cut platforms covered with marine Pleistocene debris.

Four test wells have been drilled for oil within the area of the Dry Canyon quadrangle but without success. Several additional test-wells have been drilled for oil short distances beyond the borders of the area, all without success. The only closed structure in the area is the Topanga anticline in the southeast part of the Dry Canyon quadrangle, where a domed closure on the fold brings the Sespe formation to the surface. However, the oil possibilities of this structure are not regarded as promising since the drilling of a well on the crest of the dome by the Standard Oil Company of California. This test-well was drilled through the Sespe into the Martinez beds without finding oil. There is a slight possibility of the existence of a closed structure in the Modelo formation along the narrow coastal belt at Malibu Beach near the mouth of Malibu Creek.

INTRODUCTION

LOCATION AND SIZE OF AREA

The area described in this report is located in the central part of the Santa Monica Mountains, Los Angeles County, California, about 30 miles northwest of the central part of the City of Los Angeles, and includes about 60 square miles of mountainous terrane embracing all of the Las Flores and Dry Canyon quadrangles and the southwestern part of the Topanga Canyon quadrangle of the United States Geological Survey. The area lies immediately west of the Topanga Canyon and Reseda quadrangles, the geology of which is described in U. S. Geological Survey Professional Paper 165-C by H. W. Hoots,[1] published in 1931. The Las Flores quadrangle is located along the coast in the southern part of the area; and the Dry Canyon quadrangle, which lies to the north, includes a small area in the extreme western end of the San Fernando Valley. These two quadrangles comprise a north-south strip of country about five and three-quarters miles wide, extending from the Pacific Ocean on the south to San Fernando Valley on the north. Together, they give a cross-section more or less typical of the central part of the Santa Monica Range.

Several wells have been drilled in this area in an attempt to discover oil, but without success. Notwithstanding the unfavorable results of drilling, it is hoped that the data concerning the structure and stratigraphy of the region may be of some value in future geological studies of neighboring areas in which oil possibilities may be more promising.

PREVIOUS GEOLOGIC INVESTIGATIONS

The earliest published records of the geology of the Santa Monica Mountains were those of W. P. Blake,[2] Thomas Antisell,[3] J. D. Whitney,[4] and Jules Marcou.[5] These brief descriptions all referred to areas far to the east of the portion of the Santa Monica Range herein described.

In 1914 the California State Mining Bureau [6] published a report and geologic atlas on the petroleum industry of California, in which a geologic map of the eastern portion of the Santa Monica Mountains was included. This map, however, did not extend as far west as the region described in the present paper.

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[1] Hoots, H. W., Geology of the eastern part of the Santa Monica Mountains, Los Angeles County, California: U. S. Geol. Survey Prof. Paper 165-C, 1931.

[2] Blake, W. P., U. S. Pacific R. R. explorations, vol. 5, pp. 73-76, 1856.

[3] Antisell, Thomas, U. S. Pacific R. R. explorations, vol. 7, pp. 76-78, 1857.

[4] Whitney, J. D., Geological survey of California, Geol., vol. 1, pp. 168-171, 1865.

[5] Marcou, Jules, Report on the geology of southern California: U. S. Geog. Surveys, W. 100th meridian, Ann. Rept. for 1876, pp. 157-160, 1876.

[6] McLaughlin, R. P., and Waring, C. A., Petroleum industry of California: Cal. St. Min. Bur. Bull. 69, Atlas, Pl. 11, 1914.

In 1917, C. A. Waring[7] published a paper with a small-scale geological reconnaissance map showing a portion of the central Santa Monica Mountains east and west of Topanga Canyon.

The United States Geological Survey published a report in 1924, by W. S. W. Kew,[8] on the geology and oil resources of parts of Los Angeles and Ventura Counties. This report, which contains a large geologic map showing a part of the Santa Monica Mountains, was the first detailed description of this region to be published.

The most detailed geologic report and map of the eastern part of the Santa Monica Mountains that has been published is the one by H. W. Hoots,[9] issued in 1931 as a part of Professional Paper 165 of the U. S. Geological Survey. Hoots' report and map (W. S. W. Kew collaborated in the geological mapping) include all of the range lying to the east of the Las Flores and Dry Canyon quadrangles except a narrow strip along the west edge of the Topanga Canyon quadrangle.

In 1932 the International Geological Congress (XVI Session) issued a guide-book to the geology of southern California, prepared under the direction of Hoyt S. Gale.[10] One of the small-scale geologic maps accompanying this publication includes the extreme western end of the Santa Monica Mountains, but the geology of the area described in the present report is not shown on the guide-book maps.

R. D. Reed [11] and J. S. Hollister published a generalized tectonic map of southern California that shows in a generalized way the distribution of the rock series present in the Santa Monica Mountains, as well as some of the larger tectonic features of the range. In 1934 the writer, with U. S. Grant,[12] prepared a short paper containing a summary of the stratigraphy and structure of the Las Flores and Dry Canyon quadrangles.

Other references to the geology of the Santa Monica Mountains could be cited, but none of them include the central portion of the range described in the present paper.

FIELD WORK AND ACKNOWLEDGMENTS

The geology of a large part of the area now included in the Dry Canyon quadrangle was mapped in 1917-1922 was W. S. W. Kew, C. M. Wagner, W. A. English, and J. P. Buwalda. This geologic map, drawn to a scale 1/62500 (approximately one mile to the inch) and the accompanying report by W. S. W. Kew [13] were published by the U. S. Geological Survey in 1924 as Bulletin 753.

The rocks along the north edge of the Santa Monica Mountains, mapped at that time as belonging to the Pico formation (Pliocene), are now considered to represent the upper part of the Modelo forma-

[7] Waring, C. A., Stratigraphic and faunal relations of the Martinez to the Chico and the Tejon of southern California: Cal. Acad. Sci., Proc., 4th ser., vol. 7, No. 4, pp. 51-57, fig. 3, 1917.

[8] Kew, W. S. W., Geology and oil resources of a part of Los Angeles and Ventura Counties, California: U. S. Geol. Survey Bull. 753, 1924.

[9] Hoots, H. W., *op. cit.*

[10] Gale, Hoyt S., Guidebook 15, Excursion C-1, Internat. Geol. Cong. (XVI Session), Pl. 11, 1932.

[11] Reed, R. D., and Hollister, J. S., Structural evolution of southern California: Bull. Amer. Assoc. Pet. Geol., vol. 20, No. 12, Pl. 1, Dec., 1935.

[12] Soper, E. K., and Grant, U. S., Stratigraphy of a part of the western Santa Monica Mountains, California: Proc. Geol. Soc. of Am. for 1934, pp. 310-311 (Abst.).

[13] Kew, W. S. W., *op. cit.*

tion (upper Miocene). East of Calabasas Peak, at the southern edge of the area shown on the geologic map accompanying Kew's report, there is shown the northern end of an important anticlinal structure (Topanga anticline) which is of special interest, and the full extent of which until now has not been shown on any published map.

In 1927-29 the United States Geological Survey, in cooperation with the County of Los Angeles, re-surveyed the topography of that part of the Santa Monica Mountains lying within Los Angeles County, and new topographic maps of the area were published in 1932 on a scale of 1/24000 (2000 ft. to the inch). Because of the revisions in the age determinations of the rocks originally mapped as Pliocene, and in order to show clearly the structure of the Topanga anticline which in the past had been considered to possess some oil possibilities, it was thought desirable to map the geology of the entire Dry Canyon quadrangle on the larger scale base maps now available, rather than to show only the geology of the southern part of the quadrangle south of the area described by Kew.[14]

The paleontologic work on the identification of the fossils collected in the area was done by Dr. U. S. Grant, Associate Professor of Geology at the University of California at Los Angeles, who has given his conclusions in the following pages. Dr. Grant was assisted by Ernest H. Quayle in the identification of the fossils. Dr. Grant also collaborated in part of the geological mapping. Mr. W. D. Rankin contributed several determinations of foraminifera from samples collected by the writer from the Modelo formation. The following former students in the geology department at the University of California at Los Angeles assisted at various times in the field work: Messrs. C. E. Abel, L. A. Braden, Roland Olson, H. B. Page, and E. S. Pickett. Credit should be given to Russel R. Simonson for pebble counts and mechanical analyses of Sespe and Topanga conglomerates and sandstones, and for data concerning the various rock types represented in these formations.

The writer also wishes to express his appreciation to Mr. T. R. Cadwalader, Trustee for the Marblehead Land Company, for permission to enter the lands of the Malibu Ranch, and to Mr. Wayne Loel for the loan of aerial photographs.

PHYSIOGRAPHY

The Santa Monica Mountains form an east-west range about 45 miles long extending from the Oxnard alluvial plain in Ventura County on the west to the Los Angeles River in Los Angeles County on the east. The chain of islands which lie to the south of the Santa Barbara Channel occur as summits along a westward continuation of the same uplift, much of which is now submerged. The width of the mountain mass varies from 10 to 15 miles. The elevations vary from about 1000 feet to about 3000 feet.

The central part of the Santa Monica Mountains exhibits greater topographic relief than the eastern end of the range, described by Hoots,[15] although the highest elevations in the range are found still

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[14] Kew, W. S. W., *op. cit.*

[15] Hoots, H. W., *op. cit.*, pp. 129-130.

ILLUSTRATIONS AND TABLES TO ACCOMPANY REPORT BY E. K. SOPER ON SANTA MONICA MOUNTAINS

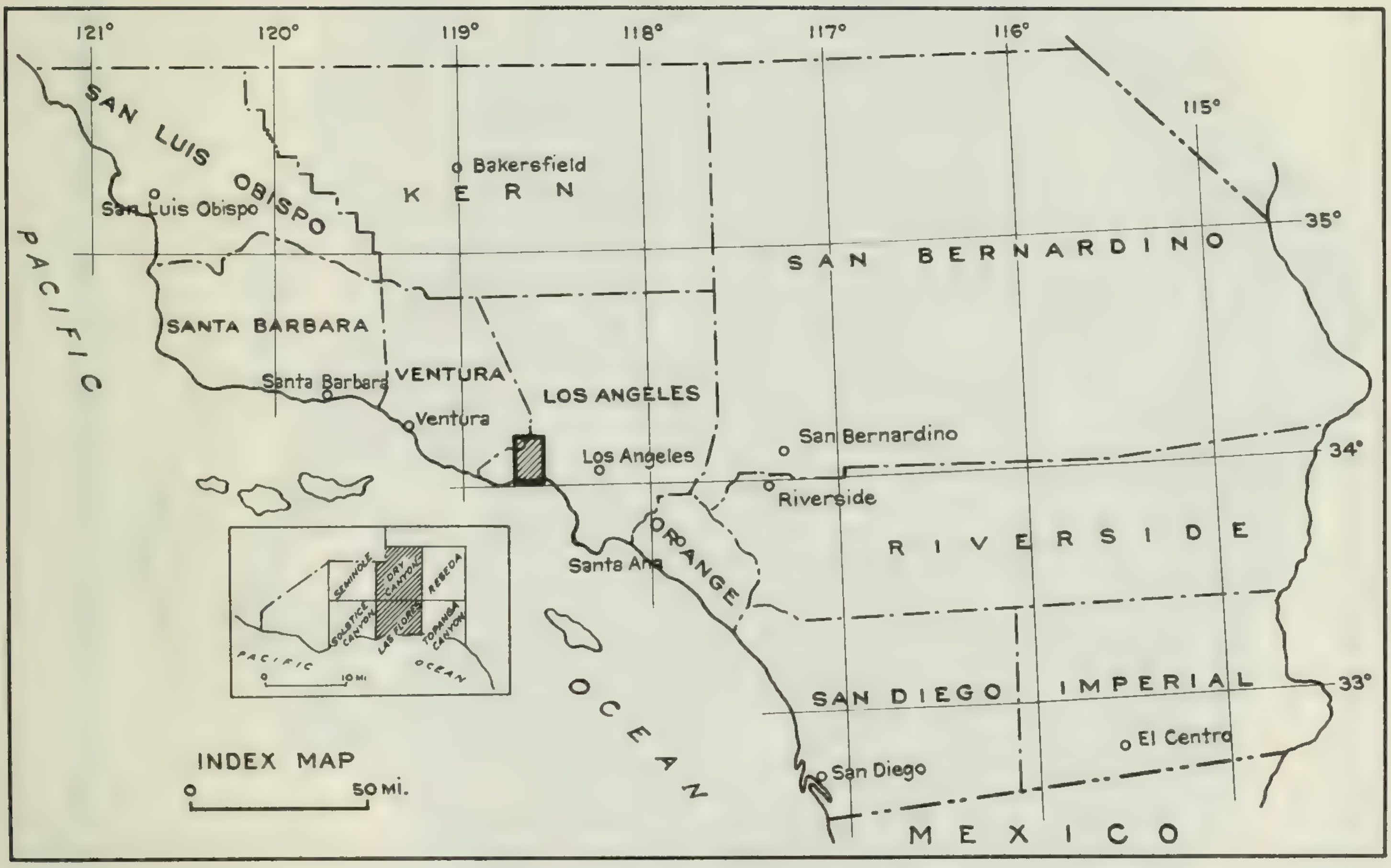

FIG. 1. Index map showing location of the Las Flores, Dry Canyon and Topanga Canyon quadrangles.

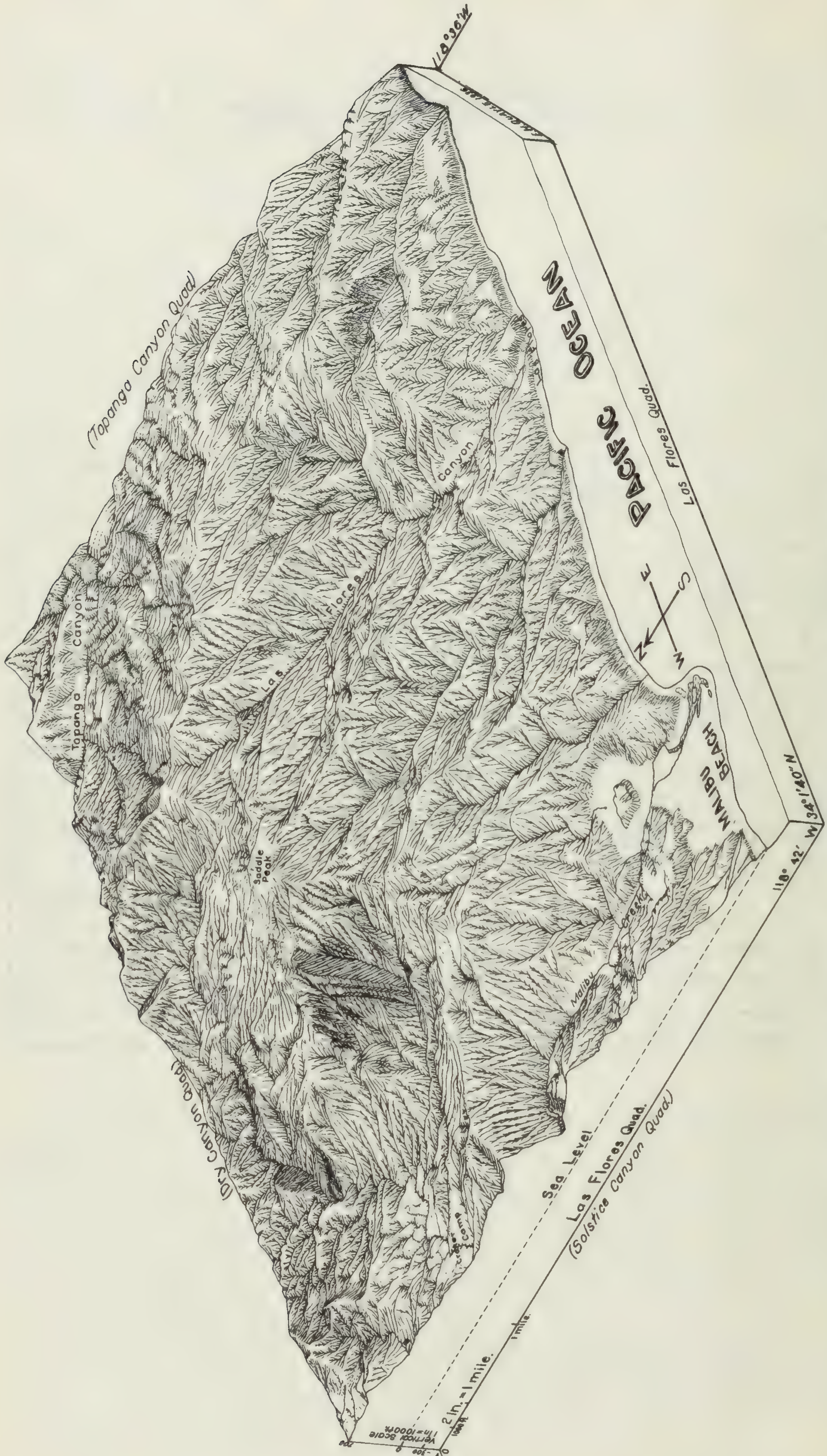

FIG. 2. Block diagram showing topography of the Las Flores quadrangle.

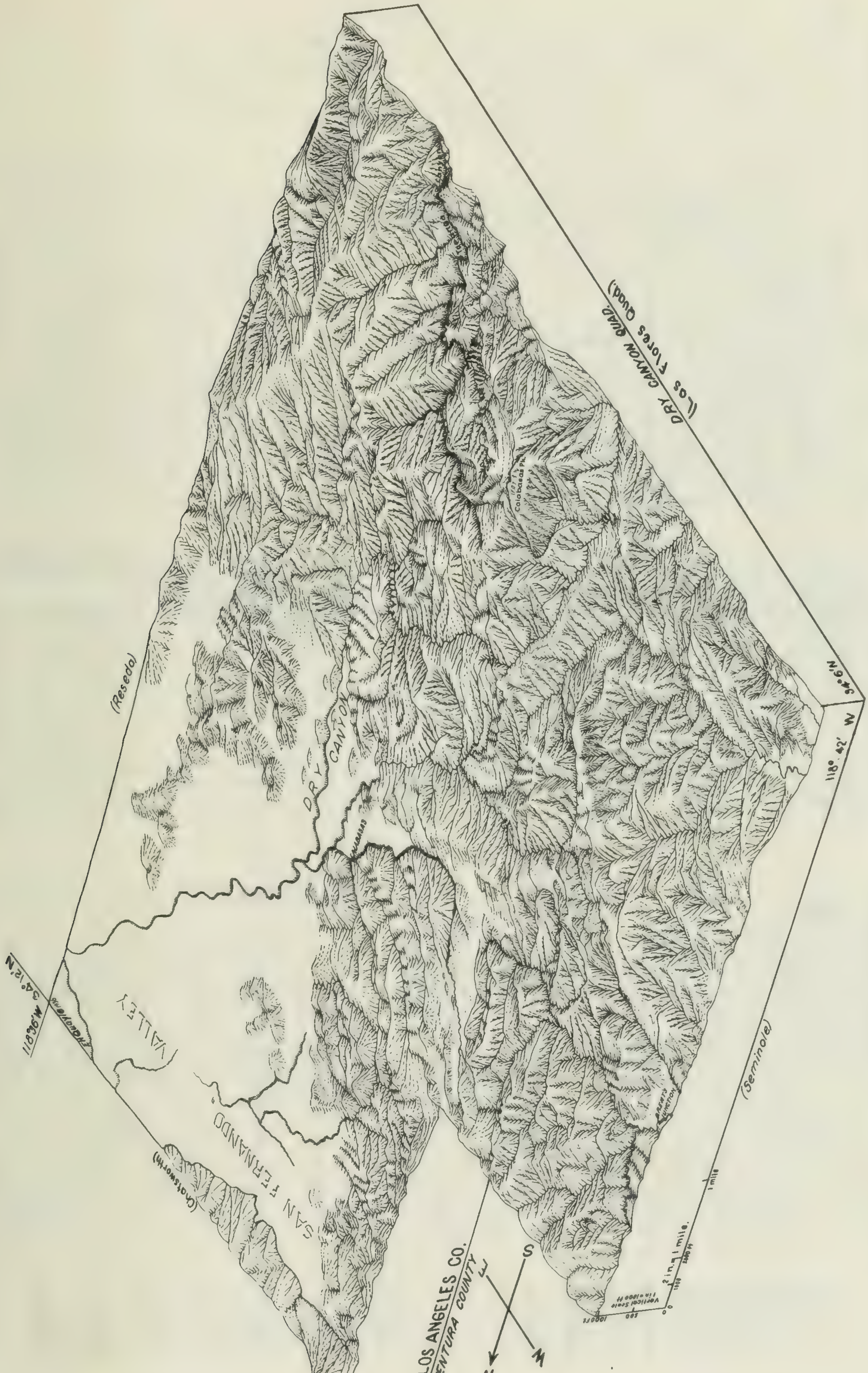

FIG. 3. Block diagram showing topography of the Dry Canyon quadrangle.

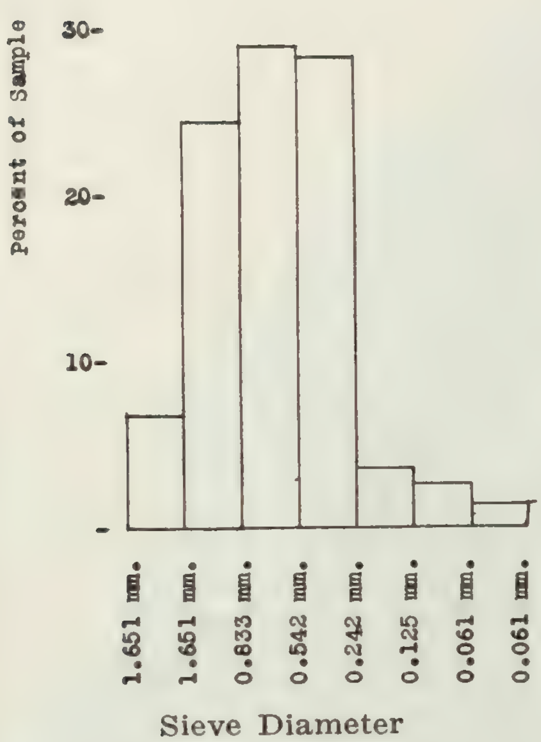

FIG. 4. Mechanical analysis of lower red Sespe sandstone from Red Rock Canyon, Dry Canyon quadrangle. (*Analysis by Russell R. Simonson.*)

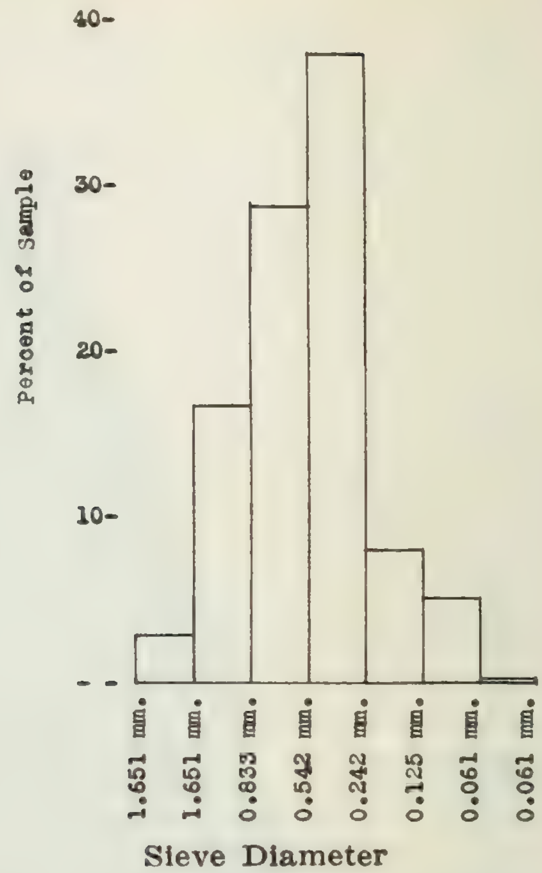

FIG. 5. Mechanical analysis of middle gray Sespe sandstone from Dry Canyon quadrangle. (*Analysis by Russell R. Simonson.*)

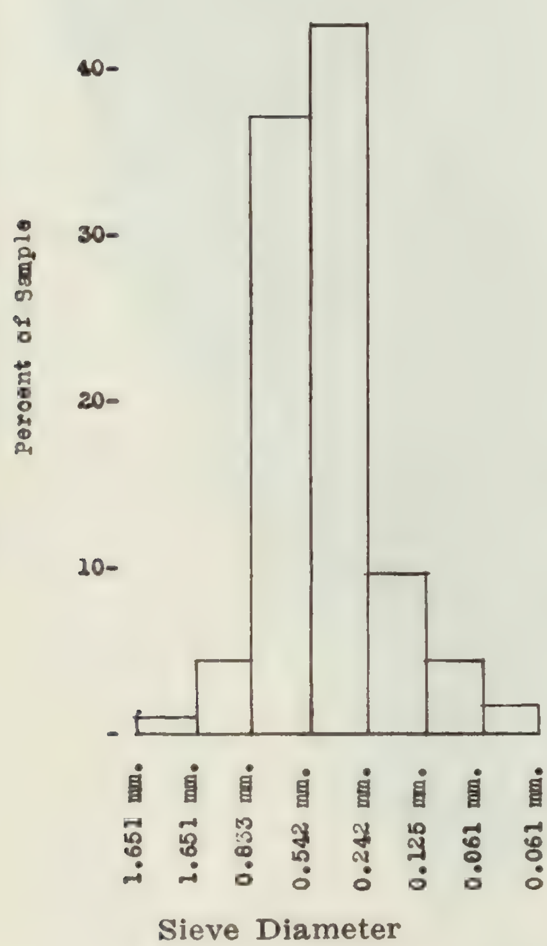

FIG. 6. Mechanical analysis of upper variegated Sespe sandstone from Dry Canyon quadrangle. (*Analysis by Russell R. Simonson.*)

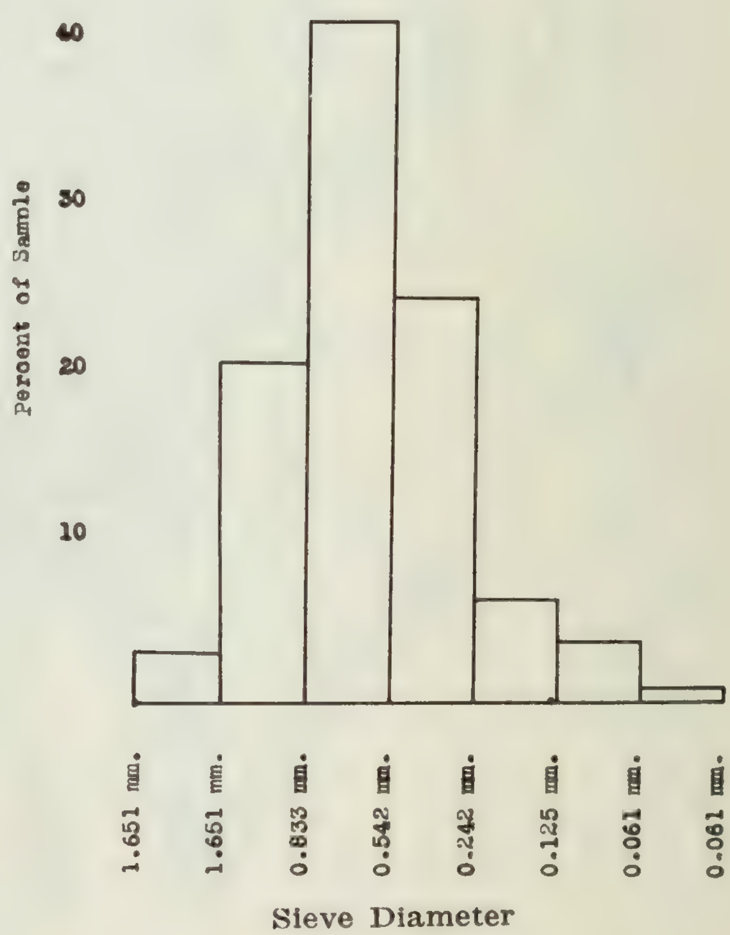

FIG. 7. Mechanical analysis of lower Topanga sandstone just above upper Sespe variegated member. (*Analysis by Russell R. Simonson.*)

Table I

Pebble Count of Lower Sespe Conglomerate

(Made by Russell R. Simonson)

	1-2	2-3	3-4	4-5	5-6	over 6	size	Total
VOLCANIC ROCKS								
MG 6 Dacite porphyry	2	2	1					5
SP 2 Meta-dacite porphyry	1	4		1	1			7
MG 1 Diabase porphyry	1	2		1				4
MG 4 Porphyrite								
SP 4 Meta-dacite	4	2	1		1	1		9
SP 5 Dacite	4	2	2	2				10
SP 6 Meta-dacite	3	3	2	1	2	1	7"	12
SP 7 Meta-rhyolite breccia	2	1		2				5
SP 8 Meta-rhyolite porphyry	2	3	2	2		1		10
LR 1 Meta-quartz latite	4	3	2	1	1			11
MG 3 Rhyolite porphyry	3		1					4
Andesites	2	2	2					6
Basic lavas	3	3	2		1	1	8"	10
								96
"GRANITES"								
SP 3 Epidote granite	3	2	2					7
MG 5 Quartz diorite	2	4	2			3	7"9"8"	11
SP 9 Tourmaline-quartz monzonite		1	1					2
SP 10 Gneissoid granite	4	6	4	3	1	3	7"8"8"	21
SP 11 Tourmaline-quartz diorite	1	2	1	1				5
MG 8 Quartz diorite	4	3		2		6	9"1"	15
Garnetiferous granite gneiss				1				1
Diorite gneiss	3	3	2	1				9
Pegmatite	1	2						3
Aplite		2						2
								76
SEDIMENTS AND META-SEDIMENTS								
LR 3 Tourmaline quartzite		2				1	10"	3
SP 12 Quartzite	1	4	3	2				10
LR 2 Arkosic sandstone	2	2				2	9"9"	6
MG 2 Quartzite	4	4	2	1				11
LR 4 Brecciated chert	1							1
LR 5 Serpentine quartzite		1	1	1				3
MG 7 Schistose quartzite	3	4	1					8
LR 9 Quartzite	1	1		1				3
LR 6 Organic chert		1	1					2
LR 8 Quartzite		2						2
SP g Mica schist			2					2
Tourmaline chert		1						1
Green schist	1							1
	62	73	38	23	7	19		53

(The numbers and letters at the left refer to the labels on the specimens and thin-sections now in the collection at the University of California at Los Angeles)

Table 2

Pebble Count of Upper Topanga Conglomerate

	Size of cobbles				TOTAL
	0-1	1-2	2-3	3-4	
VOLCANIC AND META-VOLCANIC					
MG 6 Dacite porphyry	4	4			8
SP 2 Meta-dacite porphyry	3	2	1		6
MG 1 Diabase porphyry		2			2
MG 4 Porphyrite		1	1		2
SP 4 Meta-dacite	1				1
SP 5 Dacite	4	3			7
SP 6 Meta-dacite	1	3			4
SP 7 Meta-rhyolite breccia	2	2			4
SP 8 Meta-rhyolite porphyry	2	2			4
LR 1 Meta-quartz latite	5	3		1	9
MG 3 Rhyolite porphyry	2	1			3
SP c Meta-quartz latite			1		1
Greenstone	4	4	3		11
					53
PLUTONICS					
SP 3 Epidote granite					
MG 5 Quartz diorite	4	1			5
SP 9 Tourmaline-quartz monzonite		1			1
SP 10 Gneissoid granite	4	3	2		9
SP 11 Tourmaline-quartz diorite	1				1
MG 8 Quartz diorite	2	1	1	1	5
Aplite			1		1
Pegmatite			1		1
					23
SEDIMENTS AND META-SEDIMENTS					
LR 3 Tourmaline quartzite	1				1
SP 12 Quartzite	4	1	1	1	7
LR 2 Arkosic sandstone					
MG 2 Quartzite	2	1	1		4
LR 4 Brecciated chert		1			1
LR 5 Serpentine quartzite	3	2			5
MG 7 Schistose quartzite	1	2			3
LR 9 Quartzite	2				2
LR 6 Organic chert	1	1			2
LR 8 Quartzite	1				1
Greenstone	2	1			3
(Muscovite) Mica schist		1			1
SP g Mica schist	1				1
	56	41	13	3	31

(The numbers and letters on the left refer to specimens that are now in the collection at the University of California at Los Angeles)

FOSSIL LOCALITIES IN THE LAS FLORES AND DRY CANYON QUADRANGLES, SANTA MONICA MOUNTAINS (1933-1935)

Macroscopic Fossils

U C L A Number	Number on Map (Plate I)	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L966	1	Hard gray sandstone at edge of hills 1600 ft. north of coast highway and due north of "M" in Malibu Beach, Las Flores quadrangle				X	
L967	2	Dark gray hard calcareous sandstone, weathering red-brown, 900 ft. east of west edge of Las Flores quadrangle and about 3800 ft. north of coast highway				X	
L968	3	Soft gray sandstone on point of ridge about 500 ft. west of Malibu Creek and about 3000 ft. north of coast highway, Las Flores quadrangle				X	
L969	4	Top of 687 ft. hill about 1000 ft. east of center of Sec. 29, Las Flores quadrangle					
L970	5	Near top of hill (triangulation station 636) about 1800 ft. north of coast highway and 1200 ft. west of longitude 118°40'; Las Flores quadrangle. Hard brown to gray sandstone surrounded by basalt				X?	
L971	6	Hard dark-gray shale about 1100 ft. northeast of locality 5; Las Flores quadrangle				X?	
L972	7	About 1600 ft. west of the center of Sec. 29, Las Flores quadrangle			X?		
L973	8	About 1400 ft. northeast of the center of Sec. 29, Las Flores quadrangle				X	
L974	9	Sandy shale and sandstone on west side of Malibu Canyon about 250 ft. east and 900 ft. south of the north west corner of Sec. 29, Las Flores quadrangle			X		
L975	10	Hard, gray to purplish colored sandstone on east edge of Malibu Creek about 650 ft. east and 350 ft. north of the southwest corner of Sec. 20, Las Flores quadrangle			X?		
L976	11	Gray to brown sandstone on west side of Malibu Canyon about on section line 1200 ft. north of the southwest corner of Sec. 20, Las Flores quadrangle			X		
L929	13	On ridge about 1500 ft. north of the north end of Malibu dam at Malibu Reservoir; Las Flores quadrangle				X	
L927	14	At north side of trail about 1000 ft. southeast of the center of Sec. 20, Las Flores quadrangle				X	

U C L A Locality No	Number on map	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L978	15	Sandstone on ridge at 2003 ft. hill about 300 ft. west and 1650 ft. north of the southeast corner of Sec. 20, Las Flores quadrangle				X	
L926	16	Coquina bed in pebbly sandstone on ridge about 500 ft. east of locality 15, Las Flores quadrangle				X	
L935	17	About 1300 ft. east and 1000 ft. south of the northwest corner of Sec. 21, Las Flores quadrangle				X	
L936	18	About 200 ft. south and 2700 ft. east of the northwest corner of Sec. 21, Las Flores quadrangle				X	
L934	19	About 500 ft. east and 2250 ft. north of the southwest corner of Sec. 16, Las Flores quadrangle				X	
L921	20	In embankment on south side of road about 2000 ft. east of Crater Camp, in Sec. 17, Las Flores quadrangle. Fragments of large oyster shells in lens of calcareous shale included in extrusive basalt				X?	
L922	21	Dark gray, hard shale in embankment on east side of road north of Monte Nido, about 1400 ft. west and 1800 ft. south of the northeast corner of Sec. 17, Las Flores quadrangle				X?	
L937	22	About 450 ft. north and 1800 ft. east of the southwest corner of Sec. 9, Las Flores quadrangle				X	
L928	23	On trail about 1700 ft. west and 2800 ft. south of the northeast corner of Sec. 20, Las Flores quadrangle				X	
L979	24	On ridge about 800 ft. south and 1300 ft. east of the southeast corner of Sec. 30				X?	
L924	25	Sandstone and sandy shale on ridge about 100 ft. north and 650 ft. west of the southeast corner of Sec. 16, Las Flores quadrangle				X	
L980	26	Sandstone at head of Carbon Canyon, about 800 ft. south and 700 ft. east of the northwest corner of Sec. 22, Las Flores canyon				X?	
L981	27	Sandstone on Saddle Peak road about 2350 ft. south and 550 ft. east of the northwest corner of Sec. 14, Las Flores quadrangle				X?	
L982	28	Sandstone on trail about 500 ft. north of Saddle Peak road and about 1650 ft. south and 1050 ft. east of the northwest corner of Sec. 14, Las Flores quadrangle				X?	
L983	29	Sandstone about 1750 ft. north and 2200 ft. east of the southwest corner of Sec. 11, and about 650 ft. southwest up the hillside from an old cabin, Las Flores quadrangle				X?	

U C L A Locality No	Number on map	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L984	30	Conglomerate and pebbly sandstone on point of ridge about 1100 ft. south of the north edge of Las Flores quadrangle and 1350 ft. east of the line between Secs. 11 and 12				X	
L985	31	Hard sandstone in bed of creek in Hondo Canyon about 900 ft. S 72° E from locality 30				X	
L344	32	Yellow-brown, fine-grained silty sandstone and sandy shale on private road about 300 ft. south and 1800 ft. east of the northwest corner of Sec. 13, Las Flores quadrangle				X	
L986	33	Sandstone on trail leading southward up ridge from road near locality 32, Sec. 13, Las Flores quadrangle				X	
L987	34	Sandstone at end of private road southeast of locality 32				X	
L988	35	Sandstone on ridge west of Fernwood about 1250 ft. north and 2200 ft. west of the southeast corner of Sec. 13, Las Flores quadrangle				X	
L989	36?						
L990	37	Brown sandstone, north of Tuna Canyon road, about 2600 ft. south and 2800 ft. west of the northeast corner of Sec. 24, Las Flores quadrangle				X	
L991	38	Light-brown sandstone on secondary road about 2300 ft. south and 1000 ft. east of the northwest corner of Sec. 19, Las Flores quadrangle				X	
L992	39	Soft, buff sandstone in road-cut at east edge of Las Flores quadrangle, about 1650 ft. south and 1600 ft. east of the northwest corner of Sec. 19				X	
L993	40	Hard brown sandstone and conglomerate in canyon at end of trail leading northeast from end of Las Flores Canyon road, N.E.¼ Sec. 22, Las Flores quadrangle		X?			
L948	41	Fine-grained, yellowish to gray sandstone in embankment on west side of Las Flores Canyon road about 1900 ft. north and 1900 ft. west of the southeast corner of Sec. 22, Las Flores quadrangle		X			
L994	43	Brown, pebbly sandstone on point of ridge about 500 ft. north and 2150 ft. west of the southeast corner of Sec. 28, Las Flores quadrangle				X?	
L995	44	Hard brown calcareous sandstone with some limestone beds about 3000 ft. south and 2150 ft. east of the northwest corner of Sec. 27, Las Flores quadrangle		X			

U C L A Locality No	Number on map	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L993	45	Hard, brown, calcareous sandstone with some limestone beds a short distance west of private road about 500 ft. northeast of locality 44, Las Flores quadrangle		X			
L954	46	Hard, brown, calcareous sandstone with some limestone beds about 350 ft. southeast of center of Sec. 27, Las Flores quadrangle; between private road and trail leading up hillside to the north of road		X			
L996	47	Hard, brown, sandstone on private road about 3000 ft. south and 600 ft. west of the northeast corner of Sec. 27, Las Flores quadrangle		X?			
L997	48	On trail on east side of Las Flores Canyon about 2000 ft. south and 1500 ft. east of the northwest corner of Sec. 26, Las Flores quadrangle		X?			
L998	50	In small canyon about 350 ft. north of coast highway about 2300 ft. west of the mouth of Carbon Canyon, Las Flores quadrangle					X
L999	52	Calcareous shale and sandstone on trail up first small canyon east of mouth of Las Flores Canyon about 1450 ft. north of coast highway			X		
L1000	54	Sandstone and sandy shale on hillside about 200 ft. north of coast highway, about 2500 ft. west of curve in highway at "Big Rock", Las Flores quadrangle			X		
L1001	55	Sandstone and shale about 300 ft. east of locality 54, Las Flores quadrangle			X		
L1002	56	Brown, pebbly sandstone 900 ft. north of coast highway about 1500 ft. south and 500 ft. east of the southeast corner of Sec. 25, Las Flores quadrangle		X?			
L1003	57	Sandstone on trail about 900 ft. north and 500 ft. west of the southeast corner of Sec. 26, Las Flores quadrangle		X?			
L1004	58	Brown, silty sandstone on Tuna Canyon road embankment about 350 ft. north and 1250 ft. west of the southeast corner of Sec. 24, Las Flores quadrangle		X?			
L1005	59	Brown sandstone about 1000 ft. north of coast highway and about 2000 ft. south and 1100 ft. west of the northeast corner of Sec. 35, Las Flores quadrangle			X?		
L1006	60	Gray calcareous sandstone on old road about 1500 ft. north of coast highway and about 1500 ft. south and 2000 ft. east of the northwest corner of Sec. 36, Las Flores quadrangle		X?			

U C L A Locality No	Number on map	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L1007	61	Sandstone bed between two basalt flows about 400 ft. south and 2350 ft. east of the northwest corner of Sec. 8, Dry Canyon quadrangle, and about 850 ft. north of the south edge of the quadrangle				X	
L1008	62	Thin bed of hard, calcareous, sandstone associated with basalt, about 150 ft. north and 1550 ft. west of the southeast corner of Sec. 5, Dry Canyon quadrangle				X	
L1009	64	Sandstone about 200 ft. north and 2800 ft. east of the southwest corner of Sec. 3, Dry Canyon quadrangle				X	
L941	65	Sandstone bed between two basalt flows about 2000 ft. north and 100 ft. west of the southeast corner of Sec. 4, Dry Canyon quadrangle				X	
L942	66	Sandstone about 1800 ft. north and 2200 ft. west of the southeast corner of Sec. 3, Dry Canyon quadrangle				X	
L1010	68	Sandstone on section line about 1650 ft. west of the southeast corner of Sec. 34, Dry Canyon quadrangle				X	
L1011	69	Sandstone about 1500 ft. north and 2100 ft. east of the southwest corner of Sec. 34, Dry Canyon quadrangle				X	
L1012	70	Sandstone about 1300 ft. south of the center of Sec. 34, Dry Canyon quadrangle				X	
L1013	71	Sandstone about 100 ft. north and 700 ft. east of the southwest corner of Sec. 35, Dry Canyon quadrangle				X	
L1014	72	Sandstone about 150 ft. south and 1900 ft. east of the northwest corner of Sec. 2, Dry Canyon quadrangle				X	
L1015	73	Sandstone and sandy shale about 1250 ft. north and 650 ft. east of the southwest corner of Sec. 3, Dry Canyon quadrangle				X	
L1016	74	Sandstone on hill near edge of basalt about 1300 ft. south and 1100 ft. west of the northeast corner of Sec. 2, Dry Canyon quadrangle				X-	
L1017	75	Sandstone about 350 ft. southeast of locality 74				X	
L1018	76	Sandstone about 2350 ft. south and 350 ft. west of the northeast corner of Sec. 2, Dry Canyon quadrangle				X	
L1019	77	Sandstone on ridge about 500 ft. south and 1100 ft. west of the northeast corner of Sec. 6, Dry Canyon quadrangle				X	
L1020	78	Hard sandstone on hill about 800 ft. north and 100 ft. west of the southeast corner of Sec. 31, Dry Canyon quadrangle				X	

U C L A Locality No	Number on map	Description	Upper Cretaceous	Eocene (Martinez)	Vaqueros	Topanga	Modelo
L1021	79	Sandstone on hill about 400 ft. north and 2000 ft. east of the southwest corner of Sec. 32, Dry Canyon quadrangle				X	
L1022	80	Sandstone on ridge about 2400 ft. north and 1800 ft. west of the southeast corner of Sec. 32, on hill 1322, Dry Canyon quadrangle				X	
L1023	81	Hard sandstone about 2250 ft. north and 750 ft. east of the southwest corner of Sec. 33, Dry Canyon quadrangle				X	
L167	82	Greenish-brown, medium to fine-grained sandstone with interbedded gray shale cut by basalt intrusions; about 2200 ft. east and 250 ft. north of the southwest corner of Sec. 35, Dry Canyon quadrangle				X	
L168	83	Greenish-brown medium-grained to fine-grained sandstone with basalt intrusions, about 2000 ft. south and 900 ft. east of the northwest corner of Sec. 35, Dry Canyon quadrangle				X	
	84	Dark gray sandy shale in road embankment on east side of Tuna Canyon road in Sec. 31 about 1750 ft. north of Coast highway, Topanga Canyon quadrangle	X				
		Foraminifera					
	85	Light gray to white punky diatomaceous shale in road embankment on Coast highway on point of hill at east edge of Malibu lagoon near mouth of Malibu Creek, Las Flores quadrangle					X
	86	Light gray to brown punky diatomaceous shale in road embankment, Coast highway on point of hill at west edge of flood plain at mouth of Malibu Canyon, Las Flores quadrangle					X

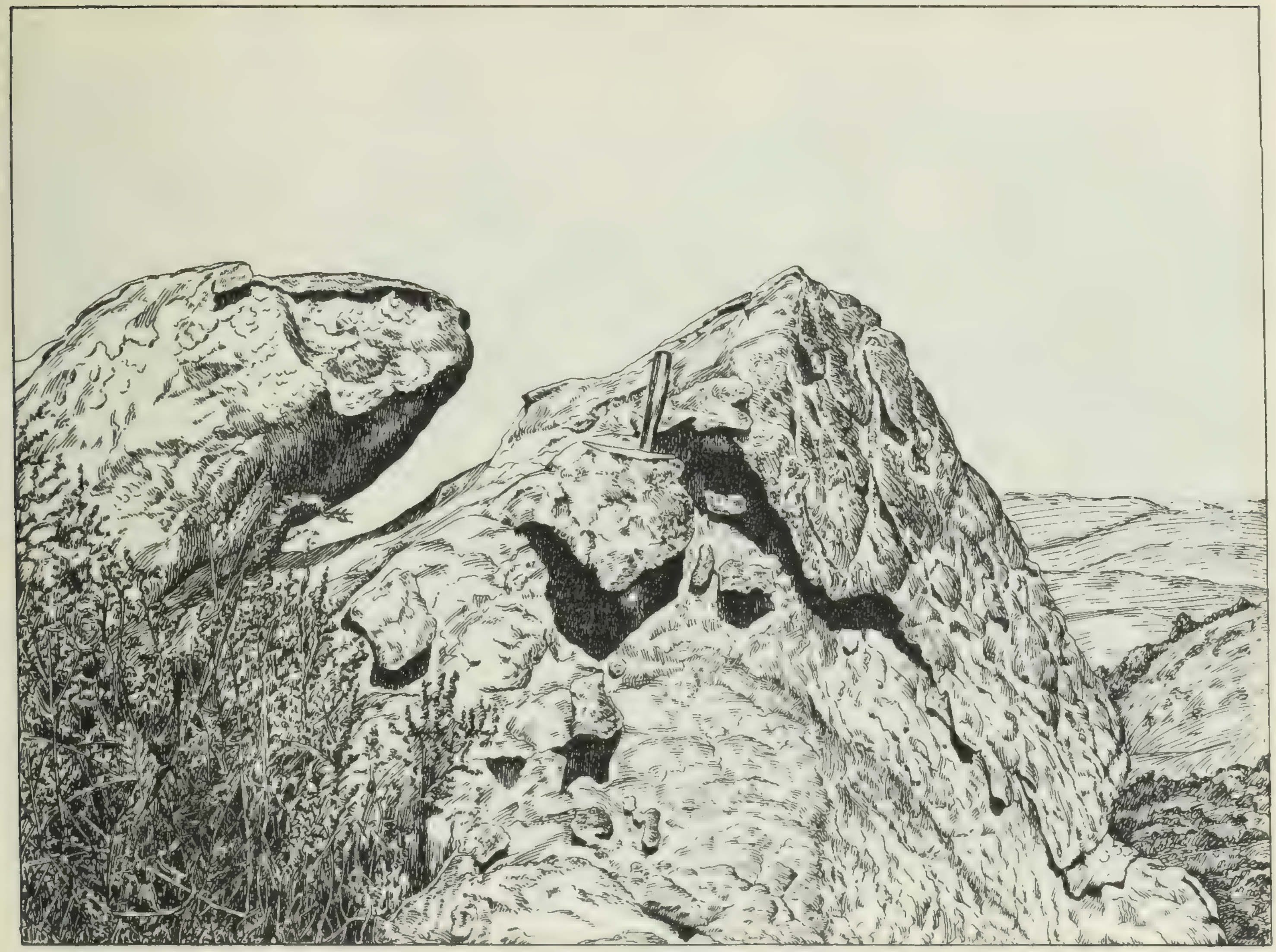

FIG. 8. Typical incrusted and weathered surface of Topanga sandstone, Las Flores quadrangle.

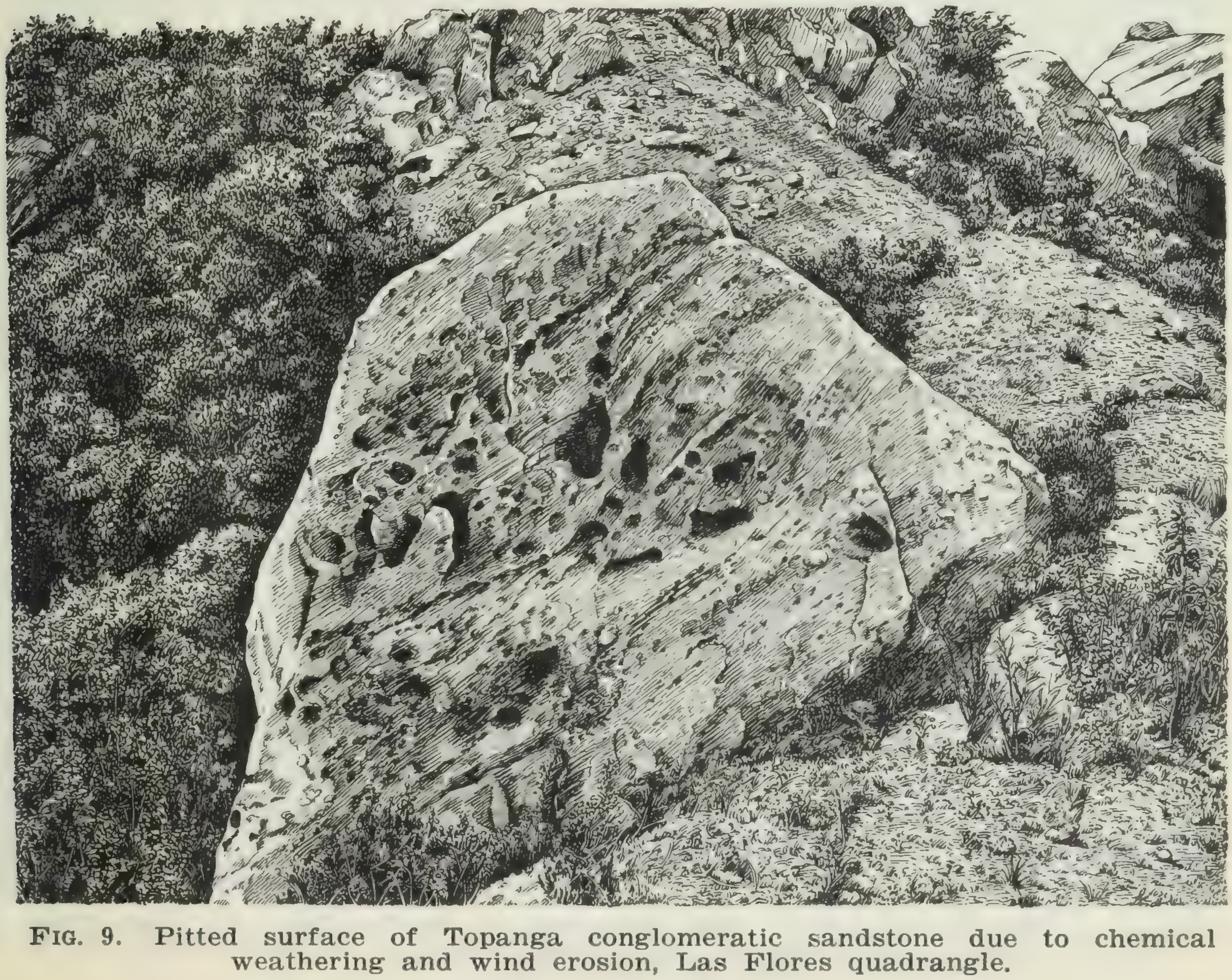

FIG. 9. Pitted surface of Topanga conglomeratic sandstone due to chemical weathering and wind erosion, Las Flores quadrangle.

FIG. 10. Concentric weathering of Topanga basalt, near Saddle Peak, Las Flores quadrangle.

FIG. 11. View eastward from ridge northeast of Saddle Peak, showing gently arched summit line beyond upper Topanga Canyon. Outline of San Gabriel Mountains is faintly visible in distance.

FIG. 12. Upper Topanga sandstone and shale showing soil 'creep' parallel to surface of hillside. Dry Canyon quadrangle.

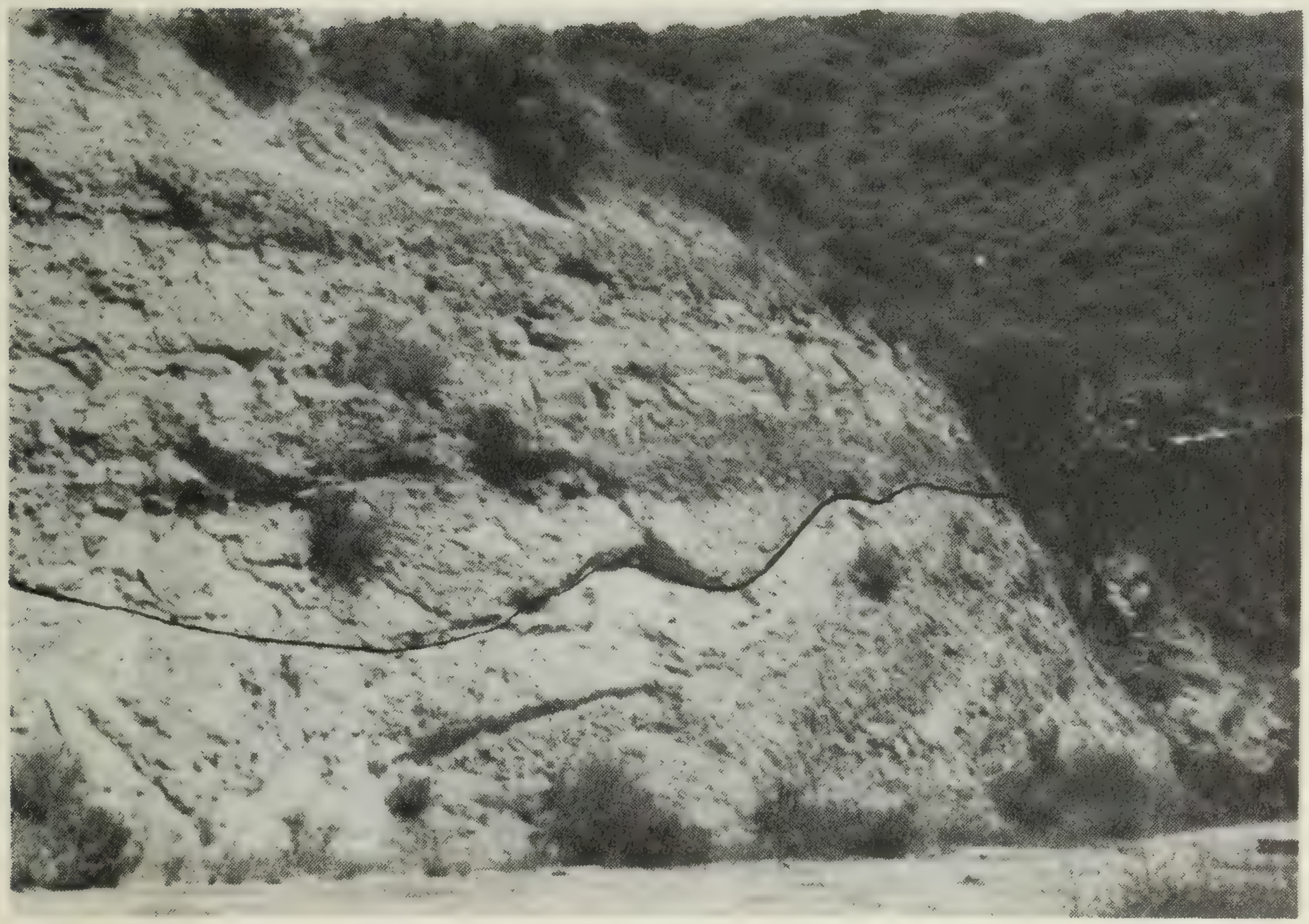

FIG. 13. Unconformity at Topanga-Modelo contact, near Mohn Springs, east edge of Dry Canyon quadrangle.

FIG. 14. Steeply-dipping Topanga sandstone showing erosional effects upon alternating hard and soft strata. Las Flores quadrangle.

FIG. 15. Lower Sespe conglomerate in Red Rock Canyon, Dry Canyon quadrangle.

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DEPARTMENT OF NATURAL RESOURCES
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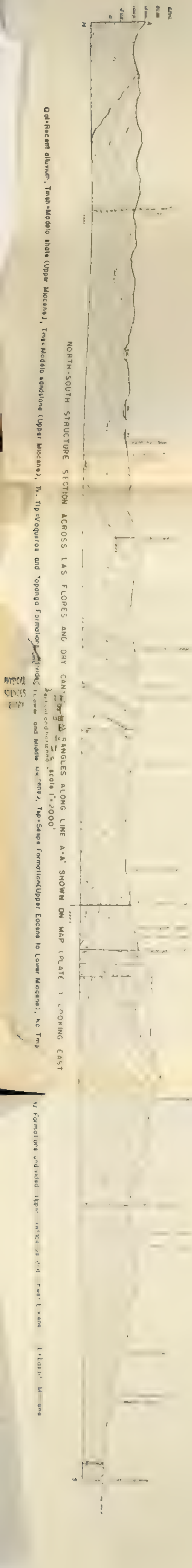
PLATE I.



further west on Bony Mountain. The elevations in the two quadrangles under discussion vary from sea level on the south to 2828 feet, the highest point in the area, on the summit of Saddle Peak, in Sec. 15, in the central part of the Las Flores quadrangle. The highest point in the Dry Canyon quadrangle is 2161 feet on Calabasas Peak, in section 3, in the south-central part of the quadrangle. The lowest point in the Dry Canyon quadrangle is about 790 feet, on the floor of the San Fernando Valley, in the extreme northeast corner of the area. These elevations compare with 2125 feet and 2000 feet, the highest points respectively in the Reseda and Topanga Canyon quadrangles adjoining the area on the east.

A noteworthy feature of the physiography is the crest line, or divide, located far to the north of the highest peaks, nearly all of which occur as prominent elevations on spur ridges which extend southward from the watershed. This feature probably is the result of the northward shifting of the divide resulting from the more rapid rate of erosion on the south flank of the range.

Another noteworthy feature of the physiography of this area is the fact that the divide, which has a general east-west trend in the east half of the Santa Monica Range, turns abruptly to the north in the south-west part of the Dry Canyon quadrangle and trends northward to the Simi Hills, whence it turns westward along the summit of the Simi Hills to a point west of Simi Peak, near the head of Lindero Canyon. At this locality the divide makes an abrupt bend to the south near the head of Russell Valley, where it again turns westward and follows a general west-southwest trend to Mugu Point on the coast. The Simi Hills, which form a northeast-southwest trending link, join the Santa Monica Mountains with the Santa Susana Mountains to the north. Because of this relationship, the Simi Hills shed the drainage in four directions; eastward into the San Fernando Valley; southward through the Santa Monica Mountains to the Pacific Ocean; westward to Pleasant Valley, and the Oxnard Plain; and northward to Simi Valley.

The area under discussion exhibits several structural features which may have influenced the development of the abrupt northward swing of the topographic divide described in the preceding paragraph. Among these structural features are the following: (1) The definite anticlinal character of the eastern part of the range becomes obscure toward the west and is no longer apparent in the area of the Las Flores and Dry Canyon quadrangles. Here the dominating east-west structural trend of the mountains has superimposed upon it a strong north-south belt of folding, especially in the Dry Canyon quadrangle; (2) no comparable north-south trending folds have been observed elsewhere in the range; (3) west of the Las Flores and Dry Canyon area the east-west strike of the formation again predominates. Field work by the writer and others [16] indicates that this east-west structural trend continues, without important north-south flexures, to the extreme western end of the range at Mugu Point. It is believed that the strong belt of north-south folding influenced, if it did not control, the abrupt northward bend in the topographic divide which is such a conspicuous feature

[16] Kelley, Vincent C., Geology of the westernmost Santa Monica Mountains, California: Proc. Geol. Soc. of Am. for 1934, p. 311 (Abst.); *also* Geological map of the western end of the Santa Monica Mountains between Sycamore Canyon and Mugu Point (Unpub.); *also* Unpublished data supplied by Wayne Loel.

of the topography of this area, and which connects the Santa Monica Mountains with the Simi Hills.

The crest of the range in the area herein described is fairly even, although less so than farther east. The larger canyons on both the north and south flanks of the monutains are steep-sided and rugged. Those on the south side of the divide show a marked steepening and narrowing of the canyon walls about one-third of the distance above the canyon floors, which suggests important rejuvenation of the streams at a fairly late stage in canyon development.

The even character of the summit areas and the flat-topped ridges indicate that they are remnants of an older surface which had been reduced by erosion to low, rolling hills or to a gently undulating plain prior to the uplift which produced the present mountains. The area was probably undergoing erosion throughout Pliocene and Pleistocene time. There is no evidence to suggest that the pre-Pliocene formations which comprise the rocks of the area were ever covered by Pliocene or Pleistocene sediments. During mid-Pleistocene time, or later, this old erosion surface was elevated by the uplifts which are known to have affected much of the California region at that time. The present topography of the Santa Monica Mountains has been developed by the erosion and dissection of the uplifted area since this uplift or succession of uplifts occurred.

Along the coast at the southern base of the mountains within the area under discussion there are remnants of two distinct, elevated, cliff-backed, wave-cut terraces which slope gradually seaward, above the present beach-level terrace now in course of active production. These terraces have been described by the late Dr. W. M. Davis,[17] who applied the names *Malibu* to the higher terrace, and *Dume* to the lower terrace. In the Las Flores quadrangle only small remnants of the Malibu terrace remain; but remnants of the Dume terrace are still distinctly recognizable at elevations of about 300 feet above sea level. Both elevated terraces became tilted toward the west as a result of uplifts which have affected the Santa Monica Mountains so that the lower, or Dume terrace, which lies at an elevation of about 300 feet above sea level in the eastern part of the range, stands at an elevation of about 100 feet on Dume Point, and disappears at sea level to the west of Dume Point. The higher, or Malibu terrace, was also involved in this tilting.

Davis has related the changes of sea level which were responsible for the cutting of these platforms to the formation and melting of great continental ice sheets. He believed that the subaerial deposits stripped from the adjacent highlands and deposited upon the lower and upper elevated platforms represent the local work of two glacial epochs, while the abrasion of the three platforms (including the one now being cut by the sea) represents two interglacial epochs and the present post-glacial epoch.

STRATIGRAPHY

The accompanying table gives a list of the rock formations exposed in the area in their stratigraphic sequence, together with data concerning their lithologic characteristics and thicknesses.

[17] Davis, W. M., Glacial epochs of the Santa Monica Mountains, California: Bull. Geol. Soc. of Am., vol. 44, No. 5, pp. 1041-1133, Oct., 1933; *also* Shorelines of the Santa Monica Mountains, California: Bull. Geol. Soc. of Am., vol. 43, No. 1, p. 227, March, 1932 (Abst.); *also* Glacial epochs in the Santa Monica Mountains: Proc. Natl. Acad. of Sci. vol. 18, No. 11, pp. 659-665, Nov., 1932.

Rock Formations Exposed in the Las Flores and Dry Canyon Quadrangles, Western Santa Monica Mountains

Geologic Age	Formation	Approximate thickness (feet)	Description
Recent	Marine sands, Alluvium.	0–15 0–100	Beach sands along coast. Sands, gravels, silts, soils. Stream channel deposits and valley fill.
Pleistocene	Alluvial deposits on raised marine platforms. Marine terrace deposits	0–50 0–25	Breccia, conglomerates, sands, silts. Fossiliferous sands and gravels.
Unconformity			
Upper Miocene	Modelo formation	4600 (max.)	Marine. Mostly shale. Upper part soft, white to light gray shale; diatomaceous in places; with few thin, lenticular beds of sandstone. Lower part hard, platy, siliceous shale, with chert, alternating with soft, brown, formaminiferal shale, with thick, lenticular beds of coarse to fine sandstone separating it from upper siliceous member.
Unconformity			
Middle Miocene Lower Miocene undivided	Topanga formation and Vaqueros formation	12000 (max.)	Marine. Where recognizable, Vaqueros consists of fossiliferous, soft to hard, gray to brown, sandstone and shale with some thin calcareous beds. Topanga consists of fossiliferous, hard, brown to gray sandstone and conglomerate in lower part; soft, brown shale with interbedded sandstone in upper part; intercalated with intrusive and extrusive basalt, and flow breccias.
Lower Miocene (?) Oligocene (?) Eocene (?) undivided	Sespe formation	1600–3275	Non-marine. Soft, red, maroon, gray to white, unfossiliferous conglomerate and sandstone, and sandstone with thin beds of red, green and purplish shale at top.
Unconformity			
Paleocene and Upper Cretaceous undivided	Martinez formation and Chico formation undivided	4900–7500	Marine. Where recognizable, Martinez formation consists of soft, gray to brown, fossiliferous shale with some sandstone. Chico formation consists of hard, dark-gray, coarse, massive conglomerate and sandstone, with subordinate amounts of hard, gray shale. Very few fossils.

UPPER CRETACEOUS AND PALEOCENE ROCKS

Chico and Martinez Formations

In the southeastern part of the Las Flores quadrangle and in the adjacent part of the Topanga Canyon quadrangle there is a considerable area occupied by rocks of upper Cretaceous age (Chico (?) formation) and of Paleocene age (Martinez formation). These rocks do not crop out in the northern part of the Las Flores quadrangle nor at any place in the Dry Canyon quadrangle. Because of their general lithologic similarity, the scarcity of fossils, the complications due to faulting, and the heavy cover of vegetation, it has been possible at only a few localities to separate these rocks in the field.

The upper Cretaceous rocks of the area are referred to in this report and shown on the accompanying map as "Chico," although no fossils have been found in the area which would definitely establish the age of the formation as equivalent to the type Chico. Previous investigators have found numerous upper Cretaceous fossils in what is apparently a continuation of this formation in adjoining areas,

and have mapped the formation as Chico. Therefore the present writer has designated as Chico the rocks below the Martinez, to indicate their correlation with the same formation elsewhere in the Santa Monica Mountains. The rocks of the Chico formation, where recognizable, are similar to those in the Topanga Canyon quadrangle described by Hoots.[18] They consist of conglomerates, sandstones, and shales, and form a westward continuation of the area of Chico-Martinez rocks mapped by Hoots in the vicinity of Topanga Canyon. The only Cretaceous fossil found in the area described in the present report was an *Inoceramus* which occurred in hard, dark-gray, sandy shale in the embankment on the east side of Tuna Canyon road in the Topanga Canyon quadrangle about 1800 feet north of the coast highway (fossil locality 84). The lowermost strata found in the area consist of dark-gray shales near the coast. Overlying these shales, coarse, massive, dark-gray conglomerate occurs with subordinate amounts of hard, gray shale and sandstone, which are considered to be of probable Chico age because of their stratigraphic relation to the overlying fossiliferous Martinez beds. The massive Chico (?) conglomerate is made up of very smooth, well-rounded cobbles, both spherical and ellipsoidal in shape, of an average size of from four inches to six inches on the long axes, but occasionally up to one foot in diameter. The cobbles consist mainly of fine-grained, dense, gray-colored, highly quartzose to flinty rocks including much quartzite. It is noteworthy that almost no schist or gneisses were observed among the cobbles. The matrix of this conglomerate consists of fairly clean, brownish sandstone, quite different in appearance from the matrix in the various conglomerate members of the Miocene formations.

Although it has been impossible to separate the Chico formation from the Martinez formation in the field with sufficient accuracy to justify mapping the boundaries between them, it is believed that the approximate distribution of the two formations may be determined from fossil collections identified as Martinez in age, and from the stratigraphic relation of these fossiliferous beds to the underlying rocks in which the only identifiable fossil which could be found was the *Inoceramus* of upper Cretaceous age (fossil locality 84).

Fossils of definite or probable Martinez age have been found at eleven localities: (locality numbers 40(?), 41, 44, 45, 46, 47, 48, 56(?), 57(?), 58(?), 60(?). At several of these localities the material was so poorly preserved that definite indentification was impossible. Dr. U. S. Grant has identified the following fossils from this formation: *Cucullaea mathewsonii* Gabb; *Crassatillites* (?) *branneri* Waring; and a poorly preserved *Turritella* which resembles *T. pachecoensis* Stanton. In general, the Chico rocks are confined to a narrow strip along the coast in the southeastern part of the Las Flores quadrangle and in the southwest corner of the Topanga Canyon quadrangle. The rocks of the Martinez formation occur immediately north of the Chico, and extend northward about one and one-half miles to the central part of the Las Flores quadrangle. The best Martinez fossil collections from which definite age determinations could be made were found in sections 22 and 27 in the south-central part of the Las Flores quadrangle.

[18] Hoots, H. W., *op cit.*, pp. 90-93.

The rocks containing Martinez fossils consist of fine-grained, buff or light-brown sandstone, overlain by brown conglomeratic sandstone which grades upward into brown conglomerate. Thin beds of soft-brown to gray shale, and buff, calcareous beds are numerous in the sandstone members of the sequence. It is noteworthy that the algal limestone reefs which form a conspicuous feature of the Martinez in the Santa Ynez Canyon and Temescal Canyon region to the northeast, described by Hoots,[19] do not occur in this area.

The unseparated Chico-Martinez formations are in fault contact with all other formations in this area except in the central part of the Las Flores quadrangle, where the Martinez is overlain by the Sespe beds. Although there is no change in the strike of the formations above and below this contact, there is a definite break in the sequence of sedimentation at this horizon, for the entire marine Eocene seems to be missing. No fossil evidence suggesting the presence of these formations has been found in the area. It is possible, as will be explained later, that the basal Sespe beds may represent a nonmarine phase of upper Eocene sedimentation; but even if this is the case, the lower and middle Eocene section seems to be missing.

No accurate measurements of the thickness of the undifferentiated Chico-Martinez formations can be made in this area because of complex faulting which has broken the Chico-Martinez rocks into several discontinuous blocks. Measurements indicate a combined thickness of from 4900-7500 feet for the Chico-Martinez formations in the Las Flores quadrangle, as compared with about 8000 feet in the region a few miles to the east.

EOCENE (?) AND OLIGOCENE (?) ROCKS

Sespe Formation

The most distinctive mappable sedimentary formation found in the Las Flores-Dry Canyon area consists of a rather narrow belt of soft, unfossiliferous conglomerates, conglomeratic sandstone, and coarse to medium-grained sandstones, of non-marine origin, which exhibit a prevailing red or maroon color. The color of these beds, however, is not always a safe criterion for their recognition, since it may change abruptly from red to light gray or nearly white along the strike. These prevailingly red beds occupy the same stratigraphic position as the red beds to the east, mapped and described by Hoots,[20] as of questionable Sespe age. The red beds of the Las Flores quadrangle have been traced by the writer into the area of red beds to the north and west, mapped and described by Kew[21] as Sespe. Because of the lack of fossils in these red beds, and the fact that throughout the Santa Monica Mountains they underlie fossiliferous middle or lower Miocene strata and rest upon Paleocene or Cretaceous beds, they are believed to belong to the Sespe formation. This does not necessarily imply that they represent the same stratigraphic horizon as the type locality in Sespe Canyon, about 18 miles to the northwest.

[19] Hoots, H. W., *op cit.*, pp. 91-93.
[20] Hoots, H. W., *op cit.*, p. 93.
[21] Kew, W. S. W., U. S. Geol. Survey Bull. 753, Pl. I, 1924.

Stock[22] has shown from studies of the mammalian fauna that the age of the lower part of the Sespe formation, as represented in the Simi Hills in Ventura County, is upper Eocene. Stock has also shown that the middle part of the Sespe formation as represented in the Las Posas Hills in Ventura County is either upper Oligocene or lower Miocene. Sespe beds elsewhere have been considered as equivalent to marine strata correlated with the lower Miocene. The "Sespe formation" represents a series of non-marine deposits, the accumulation of which began in late Eocene time and continued through the Oligocene and into early Miocene time. The lower portions of the Sespe formation may therefore be the time equivalent of the marine upper Eocene, and the upper portion of the Sespe may be of the same age as part of the marine Vaqueros formation of lower Miocene age. In fact, there is evidence that Sespe red beds may grade laterally into marine strata.[23] The stratigraphic relationships of the Sespe beds in the central and western parts of the Santa Monica Mountains are entirely consistent with the field evidence found elsewhere, which indicates a considerable variation in age between different parts of the formation.

In the extreme western end of the Santa Monica Mountains, where no Sespe beds are exposed, a fairly thick section of marine fossiliferous strata of lower Miocene age is found (Vaqueros formation). In the central part of the range some marine fossiliferous Vaqueros beds are present but these are only a few hundred feet thick, whereas the Sespe red beds are represented by more than 3200 feet of strata showing marked characteristics of non-marine origin. Unfortunately no fossils have been found in the Sespe beds of the Santa Monica Mountains. To the west of the Las Flores quadrangle a considerable part of the geology of the Solstice Canyon, Seminole, and Dume Point quadrangles has been mapped by the writer and the westward continuation of the Sespe formation into the Solstice Canyon and Dume Point quadrangles has been demonstrated; but as yet no fossils have been found in these red beds. Since vertebrate faunas which indicate a range in age from upper Eocene to lower Miocene have been found in the Sespe beds in various localities to the west and northwest of the Santa Monica Mountains, it is possible that more careful search may result in the discovery of a mammalian fauna in the Santa Monica Sespe beds.

The greatest thickness of Sespe represented in the area under discussion occurs in the southern part of the Dry Canyon quadrangle, where the surface exposures together with records obtained from a well drilled on the Topanga anticline (Standard Oil Company Austin No. 1) indicate a total thickness of about 3275 feet. East and south of Saddle Peak in the north-central part of the Las Flores quadrangle the thickness of the Sespe varies from 1600 feet to 2500 feet, indicating a rapid thinning to the southwest.

The best exposures of the Sespe beds in this area are to be seen in Red Rock Canyon which cuts across the Topanga anticline in the south-central part of the Dry Canyon quadrangle. On the sides of this

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[22] Stock, Chester, Eocene land mammals in the Pacific Coast: Proc. Nat. Acad. Sci., vol. 18, no. 7, pp. 518-529, 1932.

Upper Oligocene mammalian fauna from southern California: Proc. Nat. Acad. Sci., vol. 18, no. 8, pp. 550-559, 1932.

[23] Reed, R. D., Geology of California, p. 148; *also* Sespe formation: Bull. Am. Assoc. Pet. Geol., vol. 13, pp. 489-507, 1929.

canyon the greater part of the Sespe formation is exposed to view. At this locality the formation may be divided into three members as follows: (1) A lower member, the base of which is not exposed, consisting of about equal amounts of red and red brown conglomerate and red arkose sandstone; (2) a middle member, consisting of about 800 feet of coarse to fine light-gray to nearly white, medium-hard arkose sandstone, with small lenses of conglomerate; (3) an upper member consisting of about 1000 feet of soft, coarse to fine, red, yellow, green, and brown variegated sandstone and conglomerate with thin, variegated, red, purple, and green shales at the top at some localities. The variegated shale at some places grades upward into Miocene marine strata; at other places there is about 100 feet of red sandstone above the shale.

The red color of the Sespe in this area is due to the presence of dehydrated iron oxides, especially hematite, turgite, and goethite, which are present around the sand grains, in the cleavages of the minerals and in the finer, silty matrix. The high percentage of grains of fresh-appearing, slightly oxidized, orthoclase feldspar, often of a pinkish color, probably contributes to the general reddish color of the formation. Until recently it was generally believed that the "Sespe red beds" represented continental deposits which accumulated under arid conditions. Stock's [24] discovery of Sespe vertebrate fossils, which represent forms that lived in areas of fairly humid climatic conditions, at various localities and horizons in the Sespe, has cast grave doubt about the arguments for aridity in this region during Sespe time. If the red color of the Sespe is due to the degree of dehydration of the iron compounds rather than to their degree of oxidation, the color may no longer be regarded as inconsistent with the idea of accumulation in a fairly humid region.

Lower Sespe Member.

In the lower member of the Sespe, the boulders in the conglomerate average between three inches and six inches in diameter, with a maximum of about twelve inches. A noteworthy feature is the high degree of rounding exhibited by the majority of these boulders. Many varieties of rocks are represented. Table 1 shows the results of a pebble count made by Russell R. Simonson [25] in the lower Sespe typical red conglomerates from this area. This table shows that out of a total of 225 cobbles and boulders varying in size from one inch to ten inches, collected from a given plot where they were 'in place' in the matrix, 30 different rock types were identified. Quartz diorite and quartzite were commonest (26 specimens of each). Other rock types present in greatest numbers were dacite, meta-dacite, meta-rhyolite porphyry, meta-quartz latite, basic lavas, and gneissoid granite. A predominance of volcanic and meta-volcanic rocks is shown by the count and the 'granites' predominate over the sedimentary and meta-sedimentary rocks. A second count taken in the same region also showed the volcanics to predominate, but at this

[24] Stock, Chester, *op cit.*

[25] Simonson, Russell R., Conglomerates of the Sespe and Topanga formations of Dry Canyon quadrangle, Santa Monica Mountains, California: Proc. Geol. Soc. of Am., pp. 304-305 (Abst.); *also* Unpublished manuscript submitted to the Department of Geology, University of California at Los Angeles, in partial fulfillment of the requirements for the degree of Master of Arts, June 1936.

second locality the 'granites' and sediments were present in nearly equal number. The scarcity of typical schists and foliated metamorphics is of special interest, and the total absence of Franciscan rock types is noteworthy. The rock types shown to compose the lower Sespe of this area strongly indicate an eastern source. The tourmalinized suite, a unique feature of the group, are especially significant as indicating a source to the east.

A mechanical analysis of a typical sample of red sandstone of the lower member of the Sespe (Fig. 4) shows that about 80 per cent of the sandstone consists of grains varying in size from 1.651 mm. to 0.242 mm. The analysis indicates a poorly sorted sediment. Among the heavy minerals identified in the samples, hematite, magnetite, garnet, and zircon were common, with tourmaline and rutile present. Of the light minerals in the samples, quartz and feldspar comprise the bulk. Orthoclase is most common, but acid plagioclase is fairly abundant. Biotite is also a common constituent.

Middle Sespe Member.

The middle member of the Sespe formation is somewhat harder than the lower and upper members, and for this reason the outcrops stand out as conspicuous hog-backs. About 85 per cent of the beds comprising this middle member consist of light gray sandstone, the remaining 15 per cent being conglomerate. The cementing material of this member does not contain the dehydrated iron oxides which prevail in the sandstone of the lower Sespe member. This may account for the lack of red color in this and other parts of the Sespe, since the more hydrated iron compounds are yellowish in color, and tend to become red upon loss of water.

A pebble count by R. R. Simonson in the conglomerate of this middle member of the Sespe gave quite different results from the count made in the lower Sespe conglomerate. The cobbles of the middle member are much smaller than those of the lower member. In both members round to sub-round forms prevail over angular and sub-angular forms.

The commonest rock type found in the middle Sespe member is quartz porphyrite. The other most common rock types are meta-quartz latite, basic lavas, gneissoid granite, quartz diorite and quartzite. Out of a total of 155 cobbles collected from a unit area, where they were embedded in the matrix, 67 specimens were of volcanic and meta-volcanic rocks, 43 specimens represented granitoid or plutonic rocks; and 45 specimens represented sedimentary and meta-sedimentary rocks. A total of 29 different rock types were identified in the count.

One interesting point brought out by a comparison of the pebbles and cobbles in the middle and lower Sespe conglomerates is the absence in the lower member of rocks typical of the San Gabriel Mountains, and the prevalence of such types in the middle member. The quartz porphyrite, mentioned above as predominating in the middle Sespe member, has been found in place chiefly in the San Gabriel Mountains.[26] The fact that San Gabriel rock types pre-

[26] Miller, W. J., Geology of the western San Gabriel Mountains: Univ. of Calif. at Los Angeles Publications in Math. and Phys. Sci., vol. 1, no. 1, 1934.

dominate throughout the "Sespe" of the Mint Canyon region, whereas they are absent from the lower Sespe member in the Santa Monica Mountains, and first appear in the middle Sespe member, suggests that the Mint Canyon Sespe might have been deposited at about the same time as the middle part of the Santa Monica Sespe.

A mechanical analysis of the middle gray Sespe sandstone (Fig. 5) shows a much better sorting than in the sands of the lower member. An examination of the heavy minerals from the middle sandstone shows that they consist chiefly of magnetite, garnet (pink and brown), epidote, and zircon, in that order of abundance. Tourmaline, rutile, piedmontite, and topaz were present but rare. As in the lower sandstone, quartz and feldspar, which prevail among the light minerals, are present in about equal quantities. The feldspars show more alteration than they do in the lower sandstone; which, in conjunction with the better sorting of the middle member, indicates a slower rate of accumulation.

Upper Sespe Member

The upper member of the Sespe formation, which is about 1000 feet thick in the Dry Canyon quadrangle, contains only about 200 feet of conglomerate and pebbly sandstone which is near the base of the member. The conglomerate resembles that of the lower Sespe member.

A pebble count of the red conglomerate of the upper Sespe member by R. R. Simonson shows that the rock types which are present are like those in the two lower Sespe members previously described, but the proportions of the various rock types are different. A noteworthy feature is the decrease in the amount of porphyrite. A total of 127 cobbles were collected in the unit area, all 'in place' in the matrix. From this total, 22 distinct rock types were identified. The greatest variety was found among the volcanics and metavolcanics, of which meta-dacite predominated. The sediments and meta-sediments were next in order of variety of rock types, among which quartzites of various colors and textures greatly predominated. The plutonic rocks were found to be present in largest quantity but they showed the least variety of rock types, of which quartz diorite was much the commonest, with gneissoid granite second in abundance.

A mechanical analysis of a typical sample of the thick variegated sandstone of the upper Sespe member (Fig. 6) shows that about 80 per cent of the material of which it is composed consists of grains between 0.833 mm. and 0.242 mm. in size. This indicates a higher degree of sorting than in the sandstones of the middle and lower Sespe members. although it is not so well sorted as the overlying Topanga sandstone (Fig. 7). There is but little cementing material present in the upper sandstone which is soft and friable. The heavy minerals identified in a sample of this sandstone, taken about 300 feet below the Topanga contact, showed magnetite abundant; garnet, epidote and zircon common; titanite and tourmaline present; and rutile rare. Feldspar, quartz, and biotite were very abundant. The quartz-feldspar ratio was estimated to be 2:1.

Since the three-fold division of the Sespe in this area is based upon color and lithology, neither of which features are constant for

any horizon within the formation, it was not found practicable to map the three members separately throughout the area.

Southeast of Saddle Peak, in the Las Flores quadrangle, the lowermost part of the Sespe consists of a white or light gray sandstone similar to that in Topanga Canyon described by Hoots.[27] This white sandstone is overlain by red or maroon conglomerate and coarse sandstone, which, in turn, is overlain by reddish and variegated sandstone, with thin variegated shales at or near the top. The red or maroon sandstone of this middle Sespe member southeast of Saddle Peak is composed largely of fairly coarse grains of quartz and feldspar, with much biotite mica. The heavy minerals are about the same as those observed in the samples from the Dry Canyon quadrangle. The matrix is argillaceous. Interbedded with the sandstone at this locality are thin beds of variegated shale showing distinct ripple marks and mud cracks.

The petrology and probable sources of the Sespe of the Las Flores and Dry Canyon quadrangles may be summarized as follows: In the *lower member*, which is largely conglomerate, volcanic and metavolcanic rocks are abundant; gneisses, quartzites, and cherts are common; plutonic rocks are common; true schists are rare, piedmontite schist and a tourmaline suite of rocks are present. In the *middle member*, in which sandstone predominates, the conglomerates are composed of rock types similar to those in the lower member except that San Gabriel rock types, absent in the lower Sespe, are abundant. In the *upper member* in which sandstone predominates, the conglomerates are composed of rock types similar to those in the lower and middle members except that the percentages vary and the San Gabriel (?) porphyrite decreases. The sandstones show progressively better sorting from the lower member toward the top. Many of the rock types found in the Sespe, especially those showing all phases of tourmalinization, are now found '*in place*' in the Riverside region (Corona quadrangle).[28] Other rock types found in the Sespe of the Santa Monica Mountains are known to exist in place in the San Gabriel Mountains. No typical Franciscan types were found in the Sespe conglomerates nor were distinctive Franciscan minerals found in the sandstones. This, together with the other facts above stated, strongly suggests an eastern source for the material comprising the Sespe beds of the Santa Monica Mountains.

LOWER AND MIDDLE MIOCENE ROCKS

The rocks of lower and middle Miocene age represented in the Las Flores and Dry Canyon quadrangles comprise the Vaqueros and Topanga formations. Possibly the upper part of the Sespe formation may be of lower Miocene age as previously explained. At first an attempt was made to separate the Vaqueros from the lower Topanga in the mapping of the Las Flores and Dry Canyon quadrangles, but this was found to be possible at only a few localities where recognizable lower Miocene fossils could be found. Overlying the Sespe in a few places, Vaqueros fossils (*Turritella inezana*) were found overlain by strata containing abundant Topanga fossils (*Turritella ocoyana* and *Pecten nevadanus*). At most localities throughout the area under dis-

[27] Hoots, H. W., *op. cit.*, p. 94.

[28] Irving, Earl M., Unpublished manuscript submitted to the Dept. of Geology, University of California at Los Angeles in partial fulfillment of the requirement for the degree of Master of Arts, 1935.

cussion the lowermost Topanga formation could not be distinguished from the marine Vaqueros formation on purely lithologic field evidence. Therefore, the two formations have been mapped together, with the exception of the upper part of the sequence which overlies a thick series of volcanics, where the strata are of definite Topanga age. These volcanics occur mostly in the Dry Canyon quadrangle and therefore the rocks which lie above the volcanics and below the upper Miocene Modelo formation in the Dry Canyon quadrangle have been mapped separately, and represent the upper part of the Topanga formation.

Vaqueros Formation.

Strata containing abundant *Turritella inezana*, indicating the Vaqueros age of the beds (although there is doubt whether the Vaqueros is lower Miocene or Oligocene) were found in only two restricted areas in the quadrangles under discussion. One of the areas is along the coast highway between the mouth of Las Flores Canyon and Big Rock (immediately west of the mouth of Piedra Gorda Canyon) in the southeast part of the Las Flores quadrangle. Along the coast between these points there is a narrow belt of red Sespe sandstone 200 to 400 feet wide. Immediately north of this belt of Sespe sandstone there is a belt of sandy and calcareous shales and sandstones in which Vaqueros fossils were found at several places (localities 52, 54, 55 and 59). This belt of Vaqueros rocks, which trends east-west for almost 6500 feet varies in width from about 700 to 1200 feet and is in fault contact on all sides with older formations, suggesting a small down-dropped block. The thickness of this faulted belt of Vaqueros varies from 200 to 600 feet.

The other area in which well-preserved Vaqueros fossils were found at several localities (7, 9, 10 and 11) is along the bottom and lower slopes of Malibu Canyon, between the dam at the lower end of the Malibu reservoir and a point about one and one-half miles downstream. The strata at these localities, in which Vaqueros fossils were found, consist of hard, gray, brown, and red-brown sandstones and sandy shales, overlain conformably by a great thickness of sandstone of Topanga age.

No fossils which could be definitely identified as Vaqueros in age were found in the Dry Canyon quadrangle where the red beds, mapped as Sespe, are overlain with apparent conformity by sandstones and sandy shales containing a typical Topanga fauna. A noteworthy feature of the contact between the Sespe red sandstone and the overlying marine Topanga formation in the Dry Canyon quadrangle is the occurrence at this horizon of flows, sills, and dikes of basalt, which are especially prominent along the east flank of the Topanga anticline. Except for a large basalt sill near the base of the Topanga formation on the high ridge east of Stunts Ranch, volcanic rocks were not observed at this horizon in the Las Flores quadrangle.

Hoots[29] reported that marine strata which could be definitely identified as Vaqueros from their fossil fauna were not well represented in the eastern Santa Monica Mountains, although in the upper drainage area of Santa Ynez Canyon in the Topanga and Reseda quadrangles, he mapped a thick unfossiliferous series of soft, red and light gray to

[29] Hoots, H. W., *op. cit.*, pp. 93-94.

white, arkosic sandstones and conglomerates, the upper part of which he considered to be of possible Vaqueros age. At the extreme western end of the Santa Monica Range, Kelly[30] found a fairly thick series of marine sandstones and shales containing a typical Vaqueros fauna. Loel reported scarce Vaqueros fossils west of the Malibu dam and reservoir.[31] Thus, it appears that the marine Vaqueros formation in the Santa Monica Mountains thins rapidly toward the east or shoreward, in marked contrast with the non-marine Sespe formation, which thins toward the west or basinward. This again suggests that at least a part of the upper Sespe beds in the Santa Monica Mountains may represent a continental phase of deposition that may be correlated with marine beds of the Vaqueros formation, which generally have been considered to be lower Miocene in age. Schenck[32] has recently suggested that the Vaqueros formation may actually represent marine Oligocene, the apparent absence of which has long been a puzzling problem in California stratigraphy.

Topanga Formation

The Topanga formation in the Las Flores and Dry Canyon quadrangles rests conformably upon either the Sespe or Vaqueros formation, with gradational contact. In the Dry Canyon quadrangle the marine Vaqueros is either absent or unrecognizable because of lack of fossils, and the Topanga formation rests directly upon unfossiliferous red colored sandstones or variegated shales which have been mapped as Sespe. There is a prominent series of intrusive sheets and dikes of basalt with some basalt flows at this contact horizon on the flanks of the Topanga anticline, but the contact elsewhere is not characterized by volcanic intrusives. In the Las Flores quadrangle fossiliferous marine Vaqueros is represented at some places between the Sespe and Topanga formations by a thin series of sandstones and sandy shales from 200 feet to 600 feet thick. At other localities in the Las Flores quadrangle marine Vaqueros beds seem to be missing, and the Topanga rests directly upon red Sespe sandstone.

The Topanga formation in the Las Flores and Dry Canyon quadrangles consists of over 12,000 feet of sandstones, conglomerates, shales, intrusive and extrusive basalts, and volcanic breccias (agglomerates). The formation may be divided into three distinctive members: (1) a lower member consisting of about 3500 feet (maximum) of fossiliferous sandstones, conglomerates, and sandy shales; (2) a middle member, consisting of about 4600 feet (maximum) mostly of intrusive and extrusive basalts, but with some volcanic breccias (agglomerates) and also some interbedded, fossiliferous shales and sandstones; (3) an upper member, consisting of about 4800 feet (maximum) of softer sandstones, conglomerates, and shales, with few fossils.

Lower Topanga Member

The lower Topanga member, which rests conformably upon either the Sespe or Vaqueros formation, consists of about 3500 feet of hard

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[30] Kelley, Vincent C., *op. cit.*

[31] Loel, Wayne, Oral communication.

[32] Schenck, H. G. What is the Vaqueros formation of California and is it Oligocene?: Bull. Amer. Assoc. Pet. Geol., vol. 19, pp. 521-536, 1935.

massive brown and gray sandstones, conglomerates, and sandy shales. The sandstones of the lower Topanga member comprise the hardest rocks to be found in the Las Flores and Dry Canyon quadrangles, and for that reason form the highest and most rugged ridges in this part of the Santa Monica Mountains. The sandstones of this member are characterized in the outcrops by the presence of a hard surface crust of a dark brown color, developed by chemical weathering. The crust is always darker in color than the freshly broken surface of the rock.

In the coarse sandstone near the base of this member, about 50 feet stratigraphically above the Sespe formation, is a fossil horizon that can be traced for several miles. This faunal zone is especially well exposed on the east and north flanks of the Topanga anticline in the Dry Canyon quadrangle (fossil localities 30, 31, 64, 66, 68, 71, 72, 74, 75, 76, and 82). At other localities in both quadrangles this faunal zone is marked by a reef containing giant pectens and fragments of oysters. Other fossil reefs, containing oysters and other brackish water forms occur at intervals between 1700 feet to 2500 feet above the base of the member. The upper 1000 feet of this lower member consists of finer-grained brown sandstones, alternating with sandy shales which are overlain by the thick volcanic series of the middle Topanga member. The sandy shales and argillaceous sandstones near the top of the lower member carry the largest and most varied fauna of the entire Topanga formation of this area.

A mechanical analysis of the lower hard, massive Topanga sandstone showed a higher degree of sorting than in any of the sandstone members of the Sespe formation. (Fig. 7.) About 85 per cent of the grains are between 1.651 mm. and 0.242 mm. in diameter. Of the heavy minerals which are present in this lower sandstone, magnetite and garnet are by far the commonest. Other heavy minerals present but not abundant include epidote, tourmaline, hornblende, zircon, hematite, and titanite. Among the light minerals, quartz and feldspar predominate. Biotite, a very common constituent of the Sespe sandstones, is much less abundant in the lower Topanga sandstone.

Middle Topanga Sandstone and Basalt Member.

The middle Topanga member consists of a maximum of about 4600 feet of intrusive and extrusive basalt and volcanic breccia or agglomerate with associated sandstone and shale. The intrusives include dikes and sills and irregular masses, many of which are too small to be shown on the accompanying geologic map. Many basalt flows, especially near the base of the volcanic series, show unmistakable evidence of a submarine or sea-bottom origin. The lower 600 or 800 feet of basalt exhibits a well-developed pillow-structure, and the flows are interstratified with thin-bedded, fissile, black, fossiliferous shales. At numerous localities, especially in the Crater Camp and Monte Nido regions in the northwest part of the Las Flores quadrangle, layers of hard, platy, dark-gray to black shale not more than a few inches thick, containing numerous fish scales and other organic remains, were observed interbedded with thick basalt flows. At other localities in the same region calcareous shale lenses four to six feet thick, containing numerous oyster shell fragments, may be seen between thicker basalt flows. It is noteworthy that all of the occurrences of fossiliferous sedi-

ments just mentioned are confined to the lower 600 to 800 feet of the middle Topanga volcanic series and indicate the gradual advent of the submarine volcanic disturbances, which at first were intermittent and separated by brief periods of sedimentation, but which gradually increased in violence and duration, culminating in a great series approximately 4000 feet thick, made up mostly of basalt flows with some agglomeratic breccias, in which no true sedimentary material was found. In the Seminole and Solstice Canyon quadrangles to the west of this area, volcanic breccias predominate over the basalts of this volcanic sequence. Throughout the greater part of these volcanic extrusives there is less evidence of pillow structure or other sub-marine features so conspicuous in the lower part. The middle and upper parts of the volcanic flows exhibit typical vesicular and amygdaloidal textures. Some tuffaceous material is present. The amygdules are filled, in many places, with white zeolites up to one inch in diameter. At one locality in the southwest corner of the Dry Canyon quadrangle the ground is dotted white with round pieces of natrolite which have weathered out of the amygdaloidal basalt. The basalt flows occur in distinct layers in many places, which conform in strike and dip to the north-dipping monoclinal structure of the sedimentary rocks.

One of the most interesting features of the geology of the Las Flores and Dry Canyon quadrangles is the fact that this area includes the eastern limits of the great mass of volcanic extrusive rocks which make up a large part of the western half of the Santa Monica Mountains. The above-mentioned basalts lense out rapidly northeast of Crater Camp and Monte Nido. North of Stunts Ranch the volcanics are less than 2500 feet thick. Farther east where they lap around the north-pitching nose of the Topanga anticline the volcanics lense out entirely, grading into conglomeratic sandstone and shale, thus indicating the eastward limits of the middle Topanga submarine volcanic flows. There are several isolated Topanga basalt beds of probable sub-marine origin in the area mapped by Hoots, but these do not compare in extent with the basalt and agglomerate flows of the western half of the range. In the Seminole quadrangle to the west, the Topanga volcanic sequence is very much thicker than in the Dry Canyon quadrangle, so that the upper Topanga sedimentary member is represented there chiefly by volcanic extrusives. Only a few hundred feet of marine sediments separate these volcanics from the overlying Modelo formation.

The fact that the basalts in this area offer little resistance to weathering and erosion has resulted in a conspicuous topographic depression or 'bowl' which marks the area occupied by the volcanic rocks. This topographic feature is suggested by the name "Crater Camp" which has been given to the small settlement at this locality. The basalts show many conspicuous examples of concentric, or spheroidal weathering. The sandstone and shale members interbedded with the basalt in the lower part of the series, because of their greater resistance to erosion, form conspicuous 'hog-back' or cuesta ridges in the steeply-dipping monoclinal beds.

Upper Topanga Member

The upper Topanga member, which overlies the volcanic member, is found only in the Dry Canyon quadrangle and consists of about 4800 feet of poorly consolidated sandstones and coarse conglomerates. The sandstones form the lower and upper portions of the member, the conglomerate the middle portion. The upper Topanga is overlain by the Modelo formation (upper Miocene) with a well-marked angular unconformity, the differences in dip being from 20 to 40 degrees, thus making the separation of the two formations comparatively easy. This angular unconformity is more pronounced in the eastern part of the Dry Canyon quadrangle, in the vicinity of Mohn Springs, where it has been described by Hoots.[33] Near this locality an angular discordance of as much as 40 degrees has been observed.

The upper Topanga strata are overlapped by the Modelo formation so that the exposed thickness of the Topanga is extremely variable. For example, in the Dry Canyon quadrangle, the maximum thickness (about 4800 feet) occurs in the Stokes Canyon area, west of the Topanga anticline. On the northward pitching nose of the Topanga anticline, the upper Topanga (above the volcanics) is only about 3000 feet thick. On the east flank of the Topanga anticline beyond the eastern limits of the middle Topanga volcanics, the Topanga formation is almost entirely covered by the overlapping Modelo formation. A pebble count of the conglomerate of the upper Topanga member was made by Simonson[34] (Table 2). A comparison of these results with pebble counts in the Sespe conglomerates shows that in the upper Topanga conglomerate, cobbles of volcanic and meta-volcanic rocks predominate just as in the lower and middle Sespe conglomerates, and in contrast with the prevalence of plutonic types in the upper Sespe conglomerates. In the upper Topanga conglomerate, volcanic and metavolcanic types predominate not only in quantity of material but also in variety of rock types. Quartzite is very common and pebbles of white vein quartz are numerous. One pebble of white quartz collected by the writer showed minute flakes of free gold.

Foliates and porphyrites are rare in the upper Topanga conglomerate, as are also the tourmaline-quartz monzonite, tourmaline diorite, and tourmaline quartzite, which are rather abundant throughout the Sespe conglomerates. In general the pebbles and cobbles of the Topanga conglomerate are much smaller in size than those in the Sespe conglomerates, and there is a distinct preponderance of the more resistant rock types.

A list of the fossils collected from the Topanga in the two quadrangles under discussion and identified by Dr. U. S. Grant and Ernest H. Quayle is given in the accompanying table.

Partial List of Fossils from the Topanga Formation, Las Flores and Dry Canyon Quadrangles, Santa Monica Mountains

(Numbers refer to localities indicated on the accompanying map)

Pelecypoda **Localities as Mapped**

Amiantis cf. *stalderi* Clark; *73*, 82, 83.
Arca *(Anadara) osmonti* n. subsp., Reinhart ms, *32*, 82.
Arca *(Anadara) trilineata* Conrad, *32*.
Clementia (Egesta) pertenuis (Gabb), *32*, *66*, *71*, 82.

[33] Hoots, H. W., *op. cit.*, p. 102.

[34] Simonson, Russell R., *op. cit.*, p. 52.

Pelecypoda **Localities as Mapped**

Dosinia arnoldi Clark, 82.
Lucina (Here) excavata Carpenter, 82.
Lucina (Myrtea) acutilineata Conrad, 32, 82.
Macoma nasuta Conrad, 22, 32, 82.
Mytilus mathewsoni Gabb var. *expansus* Arnold, 32, 82, 83.
Ostrea eldridgei Arnold, 32.
Panope generosa Gould, 83.
Pecten (Lyropecten) cf. *magnolia* Conrad, 82.
Pecten (Vertipecten) navadanus Conrad, 5, 17, 18, 22, 26, 30, 66, 68, 71, 72.
Pholadidea penita (Conrad), 82.
Pholas (Zirfaea) dentatus (Gabb), 82.
Pinna (Pinna) n. sp., 32.
Pteria peruviana Reeve var. *rositae* Hertlein, 32.
Saxidomus nuttalli Conrad, 32, 82.
"Tivela" gabbi, Clark, 82.

Gastropoda

Calyptraea (Calyptraea) inornata Gabb, 32, 82.
Calyptraea (Trochita) trochiformis (Chemnitz), 32, 82.
Cancellaria (Calcarata) condoni Anderson, 82.
Cancellaria (Calcarata) dalliana Anderson, 82.
Cancellaria (Euclia) simplex Anderson, 82.
Crepidula praerupta Conrad, 32.
Crepidula princeps Conrad, 25. (L. 106. W. 63 H 40 mm.)
"Drillia" antiselli Anderson, 82.
"Drillia" cf. *buwaldana* Anderson, 82.
"Drillia" ocoyana, Anderson & Martyn, 82.
Fissurella rixfordi Hertlein, 32.
"Ocinebra" topangensis Arnold, 32, 82.
Polinices (Neverita) reclusianus callosus (Gabb), 78, 82, 83, 32.
Terebra cooperi Anderson, 82.
Thais trophonoides Anderson & Martyn, 82.
Turbo topengensis Arnold, 82.
Turritella ocoyana Conrad, ss., 32, 78.
Turritella ocoyana bosei Hertlein & Jordan, 22, 66, 75, 78, 82.
Turritella temblorensis Wiedey, 18, 22, 32, 44, 73, 75, 79, 82.
Turritella inezana Conrad var., 54, 55, 59, 79.
Turritella inezana bicarina Loel & Corey, 59.
"Echinarachnius" norrisi (Park).

Dr. Grant offers the following comments on these fossils:

"Most of the collections appear to indicate the Transition zone or lowest Temblor as those terms are customarily used in defining the subdivisions of the Miocene of the California coast ranges. However, the occurrence of what appears to be *Turritella inezana bicarina* Loel and Corey at Locality 59 suggests a zone well down in the Vaqueros. *Turritella temblorensis* Wiedey is the most abundant *Turritella* in the collections. Its growth lines indicate it may belong to the *T. terebralis* group. It appears to be entirely distinct from the *T. ocoyana* clan which is well represented in the collections by the variety bősei Hertlein and Jordan and Conrad's typical variety. Several well-preserved specimens of *Turbo topangensis* Arnold, including opercula, were obtained from Locality 82. One of these has the operculum wedged inside the aperture. The pustulose operculum of this little *Turbo* places it with the *Callopoma* group which is represented in the recent faunas of the eastern Pacific by *T.* (*Callopoma*) *fluctuosus* Wood, *Saxosus* Wood, *Magnificus* Jonas, *Niger* Wood, and *mazatlanica* Pilsbry and Lowe. *Turbo topangensis* has a superficial resemblance to some species of *Tectarius* Valenciennes which, however, has a horny operculum and belongs to the Littorinidae.

"As a whole the pectens appear to be poorly preserved but *Vertipecten nevadamus* (Conrad) (which is probably an older name for *Pecten bowersi* Arnold and *Pecten Kernensis* Hertlein) is rather abundant. *Clementia* (*Egesta*) *pertenuis* (Gabb) is common. Its variability here as well as in the Caliente Mountain Miocene of eastern San Luis Obispo County suggests that *Clementia conradiana* (Anderson) probably represents only an individual variation.

"The correlation of these Santa Monica Mountain fossil beds with the zones in the Kern River-Poso Creek area is difficult on account of differences in ecology. It is possible that some of the Transition faunas of the Santa Monica Mountains in the area just west of Topanga Canyon may be equivalent in age to the Jewett-Freeman silts, but the latter appear to represent deeper water. Locality 82 contains a number of species which are also found at Barker's Ranch (Zone "B" of F. M. Anderson) and if this represents identical or similar ages, then the beds in the Dry Canyon quadrangle (Loc. 82) may be equivalent to the base of the Round Mountain Silt or upper part of the Olcese sand. Such a correlation would place the lower few hundred feet of the Topanga formation in the

Dry Canyon quadrangle well up in the Temblor subdivision of the Miocene as applied to the Kern River area. This suggests that the basal Topanga beds rapidly attain lower horizons westward. This seems to be true in the areas west of the quadrangles considered in the present report.

"Echini are remarkably rare in the collections. Occasional unidentifiable fragments occur but only *"Scutella" norrisi* Pack has been identified. This species is not a typical *Scutella* but has customarily been referred to that genus.

"As a whole the faunas indicate that the marine temperature during the deposition of the fossiliferous beds was considerably higher than that of the present seas in this latitude. Similar temperatures might be encountered in shallow water south of Scammons Lagoon on the west coast of Lower California."

UPPER MIOCENE ROCKS—MODELO FORMATION

The diatomaceous shales along the north edge of the Santa Monica Mountains, described and mapped by Kew,[35] as Pliocene (Pico formation), are now considered to represent the upper part of the Modelo formation. In his report on the eastern Santa Monica Mountains, Hoots[36] mapped these diatomaceous shales as upper Modelo. He divided the Modelo into four mappable units: a lower shale and lower sandstone, and an upper shale and upper lenticular sandstone.

The present writer at first attempted to divide the Modelo formation in the Dry Canyon quadrangle into the same four units as was done by Hoots, but this was found to be impracticable because of the rapid lensing out of the upper sandstone members towards the west. Consequently only a three-fold division of the Modelo is shown on the accompanying geologic map.

Except for a few shell fragments, no mega-fossils were found in the Modelo formation in this area. Fish scales and marine plant remains are numerous. A few whale bone fragments and small pieces of petrified wood were found. Samples of brown foraminiferal and diatomaceous shale collected by the author from the highway cut on the east side of Malibu lagoon (fossil locality 85) were submitted to Wilbur D. Rankin who identified the foraminifera as belonging to the upper part of the lower Modelo shale, not higher than zone 12 nor lower than zone 8, and probably correlating with zone 9 described in Hoots' report on the eastern Santa Monica Mountains.[37]

Area in Dry Canyon Quadrangle.

In the Dry Canyon quadrangle all three members of the Modelo are present, as follows: (1) a lower member, consisting of hard, platy, siliceous shale containing abundant foraminifera, radiolaria, and diatoms; cherty at many localities; alternating with thin beds of soft, brown, foraminiferal shale; (2) a middle member consisting of soft brown to gray lenticular beds of coarse sandstone, separating the lower platy shale from (3) an upper member of soft, white to light gray, diatomaceous and foraminiferal shale, and gray, punky diatomite, containing a few thin lenses of yellowish sandstone. The Modelo rests upon the Topanga with pronounced angular unconformity. The thickness of the various members of the Modelo are variable due to the lenticular nature of the formation. The maximum total thickness of the Modelo formation as represented in the area is

[35] Kew, W. S. W., *op. cit.*, p. 64; *also* Pl. I.

[36] Hoots, H. W., *op. cit.*, pp. 101-115; *also* Pl. 16.

[37] Hoots, H. W., *op. cit.*, Pl. 27.

about 4600 feet in the north-central part of the Dry Canyon quadrangle.

Area Along Coast—Las Flores Quadrangle.

The only Modelo found in the Las Flores quadrangle occurs as a narrow east-west strip along the coast south of the Malibu Coast fault, and west of Las Flores Canyon. It is believed, however, that the Modelo formation originally was deposited throughout the area and that it has been eroded from most of the area since the post-Modelo diastrophism which elevated the region. The best Modelo exposures along the coastal belt may be seen along the coast highway on the southern ends of the spur ridges on both the east and west sides of the mouth of Malibu Canyon, north of Malibu Beach. Another good exposure of Modelo diatomaceous shale may be seen on the north side of the coast highway about opposite the tile factory east of Malibu Canyon.

PLEISTOCENE ROCKS

Marine Pleistocene.

The only marine Pleistocene deposits in the area occur as small discontinuous remnants on portions of the elevated wave-cut platforms along the coast in the Las Flores quadrangle. These marine deposits rest upon the truncated edges of steeply-dipping older strata, and are mostly covered by recent deposits stripped from the steep slopes to the north. The Pleistocene marine deposit consists of thin beds of cobbles and sands, in some of which numerous fragments of marine fossils were found. A short distance east of the mouth of Las Flores Canyon a small area of red-colored sandstone, containing marine Pleistocene fossils may be seen. This deposit was probably derived from the adjacent red Sespe sandstone cliffs against which it lies. The Pleistocene sands which dip gently to the south lie upon sandstone strata of probable Sespe age which dip steeply to the north. Between Carbon Canyon and Las Flores Canyon, on a remnant of an elevated marine platform is found a coarse, semi-consolidated dark-gray sandstone, containing many Pleistocene fossil fragments along the surfaces of stratification.

Non-Marine Pleistocene.

Non-marine sands, gravels and soils believed to be of late Pleistocene age occur as thin, discontinuous patches on the elevated marine platforms along the coast. They cover marine Pleistocene sands and gravel beds in a few places, and are, in turn, mostly covered by Recent soils and sands. The material of which the non-marine Pleistocene deposits is composed consists of poorly sorted angular rock fragments, sands and muds made up of the same rock types which occur in place on the adjacent slopes. They were deposited by streams which flowed south from the Santa Monica Mountains across the marine platform at a time when the shore was considerably farther out from its present position. The gradual shifting of the shore line landward is the result of late Pleistocene and Recent marine erosion.

RECENT ALLUVIUM

Coarse to fine unconsolidated valley and stream channel deposits cover the floor of the San Fernando Valley in the northeast part of the Dry Canyon quadrangle. Along the coast in the Las Flores quadrangle Recent sands, gravels and soils are found on the surfaces of the elevated marine terraces and along the canyon bottoms and especially along the bottom of the lower part of Malibu Canyon. Beach sands of Recent age extend continuously along the shore. Opposite the mouth of Malibu Canyon, the muds and sands which have filled the lagoon behind the sandbar of Malibu Beach are largely of post-Pleistocene age.

LIST OF FOSSIL LOCALITIES

The following table describes the localities where fossils were collected in the area. The map numbers correspond with those shown on the accompanying geological map. The U. C. L. A. locality numbers correspond with those on the specimens in the collections of the Geology department at the University of California at Los Angeles.

STRUCTURE

Without some knowledge of the geology of the area to the east, the six-mile-wide strip across the Santa Monica Mountains under discussion would give a very misleading idea of the geological structure of the range. The area embraced within the Dry Canyon and Las Flores quadrangles is of particular geological interest because it occupies approximately the middle portion of the range; to the east and west the geological structure is very different. The anticlinal structure clearly apparent in the eastern end of the Santa Monica Mountains becomes less evident toward the west. In the Topanga Canyon and Reseda quadrangles, near the western end of the area mapped by Hoots[38] and Kew, block-faulting and igneous extrusion and intrusion have obscured any anticlinal structure which once may have existed here.

Still farther west, in the Dry Canyon and Las Flores quadrangles, the structure appears to be a north-dipping monocline upon which a north-plunging anticline and two north-plunging synclines have been superimposed. (See map and structure section.) The axes of these secondary folds trend in a direction nearly normal to the east-west regional strike and topographic trend of the mountains. Along the coast in this area, at the southern edge of the range, an important east-west fault (Malibu Coast fault) separates the older formations on the north from a down-dropped narrow belt of Modelo rocks on the south. Although these Modelo rocks dip steeply to the north into the fault, it is possible that the range represents only the north flank of an intricately broken and invaded anticlinal structure, the faulted axial portion of which is now partially submerged. If the Modelo formation was originally deposited over the entire area with great angular unconformity similar to the Modelo overlap now visible in the eastern part of the range, the presence of the belt of Modelo rocks along the coast would not necessitate the assumption of any great amount of vertical displacement along the Malibu coast fault.

[38] Hoots, H. W., *op. cit.*, Pl. 16.

The Santa Monica slate (Triassic?) and the granite intrusives (Jurassic?) associated with it, which form the axial core of the domed uplift midway between Topanga Canyon and the eastern end of the range, are not exposed in the Dry Canyon and Las Flores quadrangles, nor, in fact, in any part of the western Santa Monica Mountains. The Jurassic (?) granite intrusion and diastrophism which effected the domed area of the eastern part of the range, apparently did not produce comparable effects in the western portion. In the eastern part of the range, the middle Miocene Topanga formation in many places rests upon the upturned and truncated Santa Monica slate, and both are overlapped by the upper Miocene Modelo formation with great angular unconformity. In the western part of the range the Topanga rests upon the Vaqueros and Sespe with gradational contact, and the uncomformity between the Topanga and the Modelo is less pronounced than it is farther east. The Modelo formation, if it were originally deposited over the entire area, has been eroded from the pre-Topanga formations with which it is now in fault contact.

PRE-TOPANGA DEFORMATION

The earliest deformation of which there is a record in the western Santa Monica Mountains occurred in post-Martinez and pre-Vaqueros time. It is represented by the total absence of marine Eocene and Oligocene strata, unless, as suggested by Schenck,[39] the Vaqueros formation of California is Oligocene in age, in which case the deformation would be limited to Eocene time. In the area under discussion the non-marine Sespe beds (Eocene ? and Oligocene ?) rest unconformably upon marine Martinez strata (Paleocene) and grade upward and interwedge into marine Vaqueros beds, thus recording changes of level resulting in the withdrawal and subsequent advance of a shallow sea. There is no convincing evidence that these changes of level were accompanied by any important folding or faulting in this region. The unconformity between the Sespe and the Martinez is not very conspicuous, and the change from non-marine Sespe to marine Vaqueros and Topanga strata is gradational. In the eastern Santa Monica Mountains, as pointed out by Hoots,[40] there appears to have been relatively large-scale uplift in the block of slate and granite, between Martinez and Sespe (?) or Vaqueros (?) time.

POST-TOPANGA AND PRE-MODELO DEFORMATION

One of the most important disatrophic deformations recorded in the area is that which occurred subsequent to the deposition of the Topanga (middle Miocene) marine strata. This deformation was preceded by the extrusion of large masses of lava upon the sea floor. That this interval was one of sharp uplift and folding followed by rapid erosion, is recorded in the angular unconformity of from 20 to 40 degrees which separates the Topanga and Modelo formations throughout the area. From a study limited to the area under discussion, it can not be definitely determined whether the diastrophism which occurred at this time produced anticlinal folding, as it is known to have done in the eastern Santa Monica Mountains. The deformation involved not only

[39] Schenck, H. G., *op. cit.*

[40] Hoots, H. W., *op. cit.*, p. 126.

the extrusion on the sea floor of a thick sequence of basalt flows, but many faults were formed at this time. The magmas, which in middle Topanga time began to be extruded irregularly as submarine flows, permeated the older Chico, Martinez, Sespe, Vaqueros and lower Topanga formations through which they had to rise to the surface, and formed innumerable intrusive basalt masses, many of which are dikes, but the majority of which are small and extremely irregular in shape. Many of the dikes occur along faults producing a field relationship useful in mapping the faults. The use of such a large volume of magma in late Topanga time may have helped to develop the forces of uplift which deformed all the existing formations in the area in post-Topanga-pre-Modelo time.

It is noteworthy that only one or two very small patches of volcanic rock were found within the Modelo formation. These are both intrusive, and occur adjacent to the post-Modelo Malibu Coast fault in the southern edge of the Las Flores quadrangle. To the west in the Solstice Canyon and Dume Point quadrangles and elsewhere, the writer has seen several fairly large masses of basalt in the Modelo. The evidence is clear, however, that the great majority of the volcanic extrusions and intrusions in the Santa Monica Mountains occurred during middle and upper Topanga time.

The accompanying geologic map shows the most noteworthy feature bearing upon the age of faulting in the area. In the Las Flores quadrangle, where the rocks are mostly pre-Modelo in age, faults are numerous throughout the area. In the Dry Canyon quadrangle the faults are confined to the pre-Modelo rocks in the south part of the area. The only important fault which from the field evidence in this area is definitely of post-Modelo age, is the Malibu Coast fault. This does not preclude the possibility that movements along some of the faults in the older rocks may have occurred in post-Modelo or even in post-Pliocene time.

POST-MIOCENE DEFORMATION

That post-Miocene folding and post-Pliocene uplift accompanied by faulting affected the eastern part of the Santa Monica Mountains is clearly indicated by the folded and faulted condition of the Modelo formation in that area, and by the presence there of faulted and tilted Pliocene strata. In the area described in the present report, no Pliocene rocks are known to occur. This fact, together with the very scanty distribution of the small remnants of Pleistocene deposits, make it difficult to date definitely post-Miocene deformation which affected the western Santa Monica Mountains. The faulted condition of the Modelo formation along the coast and its folded structure on the north side of the range make it certain that important post-Miocene deformation, of an orogenic aspect did affect the region. The elevated and tilted marine terraces along the coast, carrying remnants of marine Pleistocene deposits, prove that late Pleistocene or post-Pleistocene uplift occurred. Additional evidence of such late uplift is seen in the narrow, V-shaped profiles of the lower parts of most of the canyons along the coast, indicating fairly recent rejuvenation.

The post-Miocene folding which involved the Modelo formation in the Dry Canyon quadrangle produced alternating anticlines and synclines trending approximately north-south at right angles to the direc-

tion of the axes of folding farther east. While it seems probable that these folds were formed at the same time that the Modelo in the eastern part of the range was folded to form a part of the Santa Monica anticline, nevertheless such a conclusion must remain uncertain. The marked divergence of the structural trend of the post-Modelo folds in the Dry Canyon region from the regional trend of folding elsewhere in the Santa Monica Mountains, and the fact that these north-south folds do not extend south of the Calabasas fault into the Las Flores quadrangle, suggests that they may not be contemporaneous in origin with the post-Modelo folding along the Santa Monica anticline east of the Topanga Canyon quadrangle.

FAULTS

The principal faults in the area are shown on the accompanying geologic map. There are numerous small faults, especially in the Las Flores quadrangle, which are too small, or the tracing of which was too uncertain to justify showing them on the map. All of the large faults and the great majority of the smaller ones are high-angle faults. Along the extreme eastern edge of the area in Topanga Canyon several low-angle faults were observed, but these could not be traced westward beyond the canyon walls. Some of these small low-angle faults are of the thrust variety, but the great majority of the faults of the area, including all of the larger ones, are either high-angle normal faults or vertical faults.

The fault pattern shows four distinct groups based upon directional trends; (1) a northwest-southeast group represented by the Calabasas, Red Rock, Saddle Peak, Dark Canyon, Pena Canyon, and several smaller faults; (2) a northeast-southwest group, represented by several relatively short faults in the Las Flores quadrangle; (3) a north-south group, represented by the Las Flores, Malibu Canyon, Fernwood, and several smaller faults all in the Las Flores quadrangle; (4) an east-west group; represented principally by the Malibu Coast fault. It is not intended to imply from the foregoing classification that the faults in the four groups were formed at different times. However, the east-west group shows evidence of being the most recent (post-Modelo) in age. The north-south Las Flores fault appears to offset or terminate faults of both remaining groups, but does not displace Modelo rocks. Upon that evidence, the north-south faults represent the second youngest group and are pre-Modelo in age. There seems to be no convincing evidence as to the relative age of the northwest-southeast and northeast-southwest groups. Faults of each of these two groups terminate against faults of the other group; and it is of course possible that they are of the same age.

The basalt flows of the middle Topanga member are cut and displaced by four large faults of the northwest-southeast group, i.e., the Calabasas Peak, Red Rock, Saddle Peak, and Dark Canyon faults. None of these four fault lines are marked by basalt intrusives. None of these four faults could be traced across the upper Topanga member, and none of them cut the Modelo formation. Their age is thus fixed as later than the volcanic member of the Topanga and younger than Modelo. They may have developed during the Topanga volcanic out-

burst, and in that case may have served as conduits for the rising lavas which formed the middle Topanga sub-marine flows.

Many basaltic intrusions occur along certain pre-middle Topanga faults in the Las Flores quadrangle. Most of these intrusions appear to have risen along the fault fractures subsequent to the last major movements on the faults. It is noteworthy that the numerous areas of basalt which occur in the pre-middle Topanga rocks throughout the Las Flores quadrangle are mostly intrusive in nature, whereas in the Dry Canyon quadrangle, the basalts are mostly extrusive and confined to the Topanga formation. This relationship supports the theory that some of the intrusive basalts in the pre-Topanga and lower Topanga rocks represent conduits up which magmas rose in the middle Topanga time to form sub-marine flows. The principal source or center of extrusion of the great basalt and agglomerate flows of the western Santa Monica Mountains was probably to the west of this area. The vents up which the lavas rose may now be buried beneath the flows. These vents may well have been faults in pre-Topanga rocks.

The topographic reflection of the faults is in general not impressive. There are certain important exceptions to this, particularly along the Malibu Coast fault, which exhibits an eroded fault-line scarp in some places near the upper margin of marine terraces, and the Las Flores and Pena Canyon faults, along parts of which canyons have been eroded.

The Malibu Coast fault is not very conspicuous in this area; but westward along the coast, in the Solstice Canyon and Dume Point quadrangles, pronounced topographic features mark the fault zone. The bringing of the upper Miocene Modelo formation into contact with the Chico-Martinez and Sespe formations along the Malibu Coast fault in the Las Flores and Solstice Canyon quadrangles at first suggests to the observer the existence of a very large vertical displacement. However, no unusual displacement is necessary because of the probable overlapping of the Modelo onto all older formations. Because of the angular unconformity at the base of the Modelo and its overlap onto older formations, it is impossible to estimate the throw of the Malibu Coast fault.

In his report on the eastern Santa Monica Mountains, Hoots (pp. 126-127) pointed out that in the region mapped by him, "the coastal area northwest of the city of Santa Monica is one of complex structural conditions and is composed of a series of small fault blocks now largely concealed beneath Pleistocene alluvium. The faulting involved the rocks of all ages from Cretaceous to Pliocene, and it appears that this belt is an integral part of the fault zone which parallels the southern base of the range . . ." It is the present writer's opinion that the Malibu Coast fault, the trace of which has been mapped westward across the Solstice Canyon and Dume Point quadrangles and eastward to the mouth of Las Flores Canyon where it becomes submerged beneath the sea, represents the westward continuation of the same fault zone which parallels the southern base of the range to the east. The complex structural conditions mentioned by Hoots as characterizing the coastal area in the Topanga Canyon quadrangle are practically duplicated along the coast in the Las Flores quadrangle, adjacent to the Malibu Coast fault, and become even more conspicuous further west.

FOLDS

The Topanga anticline, named and mapped in part by Kew,[41] is the largest and most important fold in the area. This fold, the axis of which trends slightly west of north, plunges to the north and south from the apex of a domed area in the vicinity of Red Rock Canyon southeast of Calabasas Peak. The fold is cut off abruptly on the south by the Red Rock fault, but to the north it can be traced across the Topanga and Modelo formations for more than four miles. To the east and west of the Topanga anticline there are parallel synclinal folds which the writer has called the Topanga syncline and the Stokes Canyon syncline respectively. These synclines both plunge to the north or northwest. They may be traced northward for approximately the same distance as the Topanga anticline. At their northern extremities these north-south folds all curve slightly westward and die out or merge into east-west folds which constitute the prevailing structural trend elsewhere throughout the Santa Monica Mountains.

It is noteworthy that the north-south folding above described has been developed only in that part of the Santa Monica Mountains which lies opposite (south of) the Simi Hills, which form a north-south topographic link connecting the Santa Susana Mountains on the north with the Santa Monica Mountains on the south. The structure of the Simi Hills is essentially anticlinal with an axial trend from northeast to southwest. Thus, the folding in the rocks which border the west end of the San Fernando Valley is approximately parallel with the curving topographic margin of the valley. The folds in the enclosing hills "wrap around" the western head of the valley; this condition is typical of a structural basin.

The Red Rock fault, which terminates the Topanga anticline and Topanga syncline on the south, does not cut off the Stokes Canyon syncline, the head of which extends southward into the Las Flores quadrangle in the vicinity of Stunts Ranch.

No folds of importance occur within the Las Flores quadrangle, except the head of the Stokes Canyon syncline and the head of another north-pitching syncline southwest of Monte Nido. The structure throughout most of the Las Flores quadrangle is essentially that of a steep north-dipping monocline intricately broken by many faults. The prevalence of faulting in the pre-middle Miocene rocks of the Las Flores quadrangle and the prevalence of folding in the post-middle Miocene rocks of the Dry Canyon quadrangle is the most conspicuous structural feature of the entire area. Most of the faults are pre-Modelo in age, whereas all of the larger folds are post-Modelo. It is quite possible that the small, discontinuous folds observed on the various fault blocks in the Las Flores quadrangle are also post-Modelo in age. However, because of the absence of Modelo and post-Modelo rocks throughout most of the Las Flores quadrangle it is uncertain whether these folds were formed along with the faulting, or whether they belong to a later period of deformation.

[41] Kew, W. S. S., *op. cit.*, p. 107; *also* Pl. I.

GEOLOGIC HISTORY

The geologic history of the region is summarized in the following table:

Summary of geologic history of Las Flores and Dry Canyon Quadrangles, Western Santa Monica Mountains, during late Mesozoic and Cenozoic time

Sedimentation	Uplift folding faulting	Igneous Activity	Results	Known Area Affected
Upper Cretaceous and Paleocene undivided (Chico-Martinez)			4900-7500 feet of marine conglomerate, sandstone and shale with some thin limestone beds; (Chico-Martinez formations undivided).	Probably entire area
Eocene, Oligocene and possibly early Miocene (Sespe?)	Post-Paleocene		Erosion— Unconformity with angular discordance. Omission of marine Eocene and Oligocene strata. Deposition of more than 3200 feet of non-marine conglomerates and sandstones of prevailing red color (Sespe formation)	Probably entire area
Early and middle Miocene (Vaqueros-Topanga undivided)		Yes	Several hundred feet of marine sandstone and shale containing *Turritella inezana*, interfingering with non-marine Sespe red beds, and overlain with gradational contact by over 12,000 feet of conglomerates, sandstones, shales with included extrusive basalts and volcanic breccias.	Entire area
	Late middle Miocene	Yes	Uplift, tilting and probably folding, accompanied by much normal faulting and basalt intrusions, and subsequent erosion, resulting in pronounced angular unconformity.	Entire area
Late Miocene (Modelo)		Very little	Erosion— 4600 feet of platy, siliceous, cherty shales, diatomaceous shales, clay shales, and sandstone; a few thin beds of volcanic ash.	Probably entire area
	End of Miocene to Pleistocene		Erosion— Absence of Pliocene rocks from area indicates important post-Miocene uplift but makes exact date of uplift uncertain. Except for narrow strip along coast area probably undergoing erosion throughout Pliocene and Pleistocene time.	Entire area
	Pleistocene		Oscillations of coastal strip resulting in series of elevated wave-cut terraces, tilted toward west.	Southern part along coast
Pleistocene			Deposition of thin beds of marine Pleistocene sands and gravels on terrace surfaces, now mostly covered by non-marine wash from the mountains.	Southern part along coast
	Late Pleistocene		Uplift, accompanied by faulting along coast. Erosion.	Probably entire area uplifted

ECONOMIC GEOLOGY

Petroleum

Wells Drilled for Oil.

Four wells have been drilled for oil within the area of the Dry Canyon quadrangle, none of which were successful. The well locations are all shown on the accompanying map and section.

The Standard Oil Company of California in 1926 drilled a well known as Austin No. 1, located in the north-central part of Sec. 11, T. 1 S., R. 17 W., to a depth of 2503 feet. This well was located on the crest of the Topanga anticline, where the Sespe formation is exposed at the surface. Gas seepages in water wells had been reported in the district. Hard, dark-gray shale, believed to represent the top of the Martinez formation, was encountered at a depth of 1250 feet.[42] The well was drilled 1253 feet into the Martinez shale below the Sespe. Gas showings were reported from the formation (Martinez) in the lower part of the hole but no oil was encountered. This well location, on the very top of the Topanga anticline, which is a faulted dome with several hundred feet of closure, is regarded as structurally favorable. However, the Sespe sandstone is deeply eroded along the axis of the anticline and lacks a cap-rock or impervious cover. In the underlying Martinez shales, where small amounts of gas were present, no sandstone or porous reservoir rock was found.

At a point 1000 feet south and 1200 feet east of the west quarter corner of Sec. 26, T. 1 N., R. 17 W., a well known as Lyle W. Rucker No. 1, was drilled in 1931 to a depth of 802 feet. This test was started in the lower Modelo formation and reached the top of the Topanga formation. The bottom was in hard, gray sandstone. The location is not regarded as favorable as it is on the west flank of the Topanga syncline.

A well known as W. C. Price (Hale No. 1) located near the southwest corner of Sec. 10, T. 1 N., R. 17 W., was drilled in 1920 to a depth of 2930 feet. It is located in an east-west trending syncline to the north of the north-south folds of the Dry Canyon quadrangle. The well started in the upper Modelo formation and bottomed in Modelo sandstone (see structure section A-A'). Slight gas showings were reported at 2310 feet but no oil was encountered. The well was abandoned in 1921.

In the southeast quarter of Sec. 22, T. 1 N., R. 17 W., a well known as W. J. Martin No. 1 was drilled in 1929 to a depth of 1825 feet. The surface formation at this locality is sandstone which represents the upper part of the lower Modelo. The well bottomed in the lower Modelo formation. Fossil fish remains, commonly found in the Modelo formation, were found in the well cores. No oil or gas was encountered and the well was abandoned in 1931.

In addition to the four wells described in the foregoing paragraphs, several test wells were drilled for oil short distances beyond the borders of the Dry Canyon quadrangle. About one and one-half miles north of Ventura Boulevard and west of the west border of the area, two wells were drilled in Las Virgenes Canyon: Olympic

[42] Data supplied by geological department of Standard Oil Company of California, Los Angeles.

Petroleum Company (Hearst 1) 5935 feet deep; and Sinol Oil Company (Hearst 2) 4900 feet deep. No oil was found. Another well, Easton and Smith No. 1, was drilled to a depth of 2954 feet, a short distance northwest of Brents Junction, near the west edge of the Dry Canyon quadrangle. A fourth unsuccessful well, Pugh-Miller (Colyear No. 1) was drilled to a depth of 2527 feet at a location about one mile north of Stokes Canyon and a short distance west of the southwest edge of the Dry Canyon quadrangle.

A short distance north of the coast highway and just west of the extreme southwest corner of the Las Flores quadrangle, in Sec. 31, T. 1 S., R. 17 W., a well known as Ferguson-Francisco Petroleum Company No. 1 was drilled in 1922 to a depth of 1185 feet. No oil was found and the hole was abandoned in November, 1925. No record of the formations encountered is available.

Oil Possibilities.

The most promising structure in the area for possible oil accumulation is in the Topanga anticline with a closure of several hundred feet in Red Rock Canyon in the southeastern part of the Dry Canyon quadrangle. This is the only closed fold in the area. The dark-colored Martinez shale, which underlies the Sespe sandstone and conglomerate at this locality, has been regarded as a potential source rock for oil elsewhere in southern California. In the Simi oil field, on the north side of the Simi Valley, about 15 miles to the northwest, commercial oil is found in Sespe sandstone overlying shales of Eocene age, and oil is also obtained there in limited quantity from strata in the Eocene. Failure to find oil in the Standard Oil Company Austin well on the crest of the Topanga anticline must be regarded as highly unfavorable for the oil possibilities of the entire area. None of the folds involving the Modelo formation in the two quadrangles here under discussion show any closure, although it is possible that there may be a closed structure involving the Modelo a short distance off-shore in the vicinity of the mouth of Malibu Creek at the extreme south edge of the Las Flores quadrangle.

Throughout the Las Flores quadrangle the formations are broken into small blocks by numerous faults, and no anticlinal folds of significance exist. Along the south side of the Malibu Coast fault, the Modelo formation dips northward into the fault so that the offshore submerged area is structurally higher than the exposed Modelo adjacent to the fault north of the coast highway. If these north dips in the Modelo represent the north flank of a faulted anticline, the axis of which is submerged a short distance off shore, there would be the possibility of a structural closure in the coastal belt of Modelo. This condition is suggested by the occurrence of a conglomerate reef exposed at low tide off Malibu beach which shows a reverse dip to the south.

No surface indications of oil were seen by the writer anywhere in the area other than slight impregnations in upper Modelo shale in the Dry Canyon quadrangle. A questionable oil seepage has been reported from the marshy flat near the lagoon at the mouth of Malibu Creek, but this was not seen by the writer.

BUILDING AND ORNAMENTAL STONE

Shale.

The lower Modelo siliceous and cherty shale is quarried in a small way at many localities for slabs which are widely used in Los Angeles for paving blocks in garden walks and residential yards, as well as for ornamental masonry walls.

In the northwest corner of the Dry Canyon quadrangle there are three small areas within the upper Modelo diatomaceous shale, where the shale has been burned to a cream, red, or maroon color, producing a rock of texture and appearance similar to brick in a kiln. The heat which produced this alteration of the shale was probably derived from the underground combustion of petroleum or asphalt originally present in the rock. The combustion is somewhat similar to the subterranean burning of coal. Oil or asphalt impregnations are commonly present in the upper Modelo shales in southern California and occurrences of such shales in the process of combustion have been recorded where the shale shows "burned" effects similar to those in this area. Near the Olympic Petroleum Company (Hearst No. 1) test well, previously mentioned, there is an area of burned Modelo shale which extends into the west edge of the Dry Canyon quadrangle. Here the shale is not only burned to bright red and variegated colors but it is hard and brittle. In places the shale has been fused so that it resembles basic lava. The rock at this locality is quarried and sold for ornamental purposes under the trade name of "volcanic rock."

Sandstone and Basalt.

At a few localities in both quadrangles the harder sandstones have been utilized locally for building. Their principal use is in foundations, chimneys, and stone walls. A small amount of basalt has been quarried and used for road metal.

UNDERGROUND WATER

Adequate supplies of good water are obtained from wells in the alluvial fill of the San Fernando Valley, the west end of which extends into the Dry Canyon quadrangle. Smaller supplies of water, sufficient for domestic supply of ranchers, are available from wells in the alluvial fills of the narrow flat-bottomed arroyos which drain the north flank of the mountains in the Dry Canyon quadrangle; also in the Valley of Malibu Creek; and in the Valley of the tributary of Malibu Creek which flows westward through the Monte Nido and Crater Camp districts in the northwest part of the Las Flores quadrangle.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of California Journal of Mines and Geology.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

MARKETING MICA[1]

By Paul M. Tyler[2]

The value of mica depends chiefly upon the size of the flat sheets into which it can be split and also upon whether it is clear or stained. Muscovite (white mica) and phlogopite (amber mica) are the micas of commerce. Biotite (black mica) and other varieties are virtually unsalable. Vermiculite, an altered mica having the extraordinary property of expanding greatly when heated, preferably should not be classed commercially as mica. Mica is marketed as (1) cut or uncut block, (2) sheet, (3) splittings, and (4) wet or dry ground mica.

In the United States, mica that will not yield flat films over about $1\frac{1}{2}$ inches square, or that is ruled, rumpled, or flawed in any way, can be sold only as scrap, its sole use being for making ground mica. Only sizes that will yield rectangles $1\frac{1}{2}$ by 2 inches or larger can be classed as sheet quality; slightly smaller sizes may be classed as punch, and under certain circumstances still smaller sizes, down to about 1 inch square, may be used for splittings, which are mostly a thousandth of an inch thick or even thinner. Splittings, however, are produced in large quantities only in British India, where labor costs very little. Even there the work is done mostly by children, who not only work cheaper but have a delicacy of touch that enables them to do the splitting faster and better. No mechanical process yet devised will permit ordinary splittings to be made economically in the United States.

A great deal of apparently good, large mica is ruined by rumpling and distortion of the crystals or "books." Tangle-sheet mica splits imperfectly; ruled mica splits in ribbons across the regular cleavage planes; and wedge mica yields films that are thicker at one end than at the other. Spotted or stained mica contains thin scales or streaks of dark minerals, such as iron oxides, and is worth less than clear, transparent mica, even though for some purposes its usefulness is not greatly impaired. Clay-staining usually occurs only near the surface, the mica books being opened slightly by weathering, thereby admitting soil between the laminae, which often renders the mica useless even as scrap. Air-bells may ruin mica for use as sheets, unless the air can be removed by careful splitting.

Grading.—The small mica miner can scarcely hope to know how to appraise the value of his product, and ordinarily his appraisal would not be accepted by large buyers, who know exactly what they want. The product of any mine is mixed and contains many grades (sizes) and classes (qualities) in ever varying proportions. Even if universally accepted standards did exist with respect to certain grades and classes (which is not the case), there would still be opportunity for a difference of opinion as to the value of a mixed lot, some portions of which would yield sizes that were in active demand while other portions would not be wanted at the moment. Ordinarily, the better pre-

[1] "Reprinted from Bureau of Mines Information Circular 6997."
[2] Chief engineer, Nonmetal Economics Division, Bureau of Mines.

pared the product, the better the price that will be paid, partly for the reason that the product can be appraised more readily. On the other hand, much good mica can be spoiled by improper trimming or rifting, an experienced worker often being able to salvage a great deal of punch or even sheet sizes from material that others would classify only as waste. Trained judgment is essential, particularly when it comes to trimming out defects in rifted material; irregular pieces are likely to be worth more than the largest rectangle that could be obtained from them by close trimming. The complexity of the grading and classifying is indicated by the fact that there are fully 100 distinct products; A.S.T.M. designation D 351-33T recognizes six different qualities for each size—namely, clear, clear and slightly stained, fair stained, good stained, stained, and black stained or spotted—and intermediate classifications can be distinguished.

The following operations are performed in preparing mica for sale: (1) Cobbing and cleaning the books; (2) rifting or splitting into sheets thin enough to be cut by hand with a blade, say 0.01 to 0.04 inches thick; (3) trimming (Bengal mica is "sickle-trimmed", resulting in an irregular outline and beveled edge. Maderas mica is trimmed with a knife or guillotine, and mica from other countries is trimmed with knife, shears, or thumb); (4) grading by size; (5) classifying each size by quality; and (6) splitting to the desired final thickness, usually one mil (0.001 inch).

Production and consumption.—Although the United States is the world's largest consumer of mica, it produces normally only 15 to 35 per cent of its requirements of sheet mica and less than 5 per cent of its requirements of splittings. Domestic mines furnish almost enough punch and circle sizes, but the bulk of their yield is scrap. A good deal of finely divided mica is recovered as a byproduct of clay washing, further quantities are obtained from schists, and some scrap or waste mica is imported for grinding. Our principal importation is splittings, of which we consumed 3,500,000 pounds in 1936, about 90 per cent coming from British India and the balance from Madagascar and Canada. Domestic production of sheet mica in 1936 was 1,319,233 pounds, but only 300,773 pounds was larger than punch or circle. Imports of sheet mica aggregated less than 1,000,000 pounds, but consisted principally of larger sizes. Production of ground mica in the United States in 1936 reached an all-time record, amounting to 23,418 short tons. At present domestic mica is mined principally in North Carolina, New Hampshire, and Connecticut, but supplies are obtained from Alabama, Georgia, South Carolina, New Mexico, South Dakota, Virginia, and other States.

Uses.—The electrical industry is the principal consumer of sheet mica and splittings. However, the quantities used for stove windows, lantern chimneys, furnace peepholes, and nonbreakable goggles and sundry decorative uses are not insignificant. Ground mica is used mainly in roll roofing, although substantial quantities are consumed in making wall paper, paint, and rubber goods; miscellaneous uses include surfacing asphalt shingles, Christmas-tree snow, lubricants, annealing, concrete surfacing, foundry facings, pipeline enamels, plastic specialties, and others.

Prices.—The Engineering and Mining Journal (New York) regularly quotes various classes of mica, but any trade-journal quotations for domestic mica must necessarily be nominal inasmuch as prices must be determined chiefly by negotiation between buyer and seller on a given lot of material. Even with respect to well-standardized Indian mica, there is some latitude for price variation with respect to nominally similar grades. Reports of producers to the Bureau of Mines indicate that in 1936 waste or scrap mica was worth, on the average, $12.44 per short ton at the mines, and waste from some mines has sold as low as $6. Ground mica has sold for from about $12 a ton for byproduct or low-grade dry-ground material to over $100 for better qualities of clean, wet-ground mica, the average in 1936 for dry-ground mica being $21.97 and for wet-ground, $55.46 per ton. Punch and circle mica averaged 5 cents a pound, and for the larger sheet mica the average was 52 cents. For uncut sheet mica 2 by 2 inches, the price was from 30 to 50 cents; for 3- by 3-inch it was around 50 to 65 cents; and so on up to $3.50 to $5 a pound for 8- by 10-inch size. The effect of staining on price is illustrated in respect to high-grade Indian ruby #5 (3 to 6 square inches in area), which in 1935 was listed by dealers in the United States as worth $2.14 per pound for clear or slightly stained, $1.69 for fair stained, $1.47 for good stained, $0.54 for stained, and $0.33 for black-spotted. A similar grade of New England clear mica was listed at $1.20, and larger or smaller discounts were placed on mica from other sources, such as Brazil or Rhodesia. Generally speaking, Indian ruby mica, grade for grade and class for class, sells for higher prices per pound than other kinds of foreign or domestic mica. During 1936 Indian splittings brought from 10 cents to $1.20 a pound.

Buyers.—The following firms have indicated to the Bureau of Mines that they are buyers of mica of the kinds specified:

BUYERS OF MICA

Waste or Scrap

California.
Pacific Minerals Co., Ltd., Richmond.

Georgia.
Frank Smith, Cartersville.

Illinois.
Amalgamated Roofing Co., 6600 Central Ave., Clearing.
United States Gypsum Co., Chicago.

Massachusetts.
Huse-Liberty Mica Co., 171 Camden St., Boston.

New Hampshire.
New Hampshire Mica & Mining Co., Keene.

New York, New York City.
Barclay Chemical Co., Inc., 75 "A" Varick St.
English Mica Co., 220 East 42d St.
General Mineral Co., 96-104 Spring St.
Minerals & Insulation Corporation, 135 Prince St.
Eugene Munsell & Co., 200 Varick St.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Soeldner-Heyman Co., Inc., 149 Church St.
Varlacoid Chemical Co., 116 Broad St.

North Carolina.
Asheville Mica Co., Biltmore.
Franklin Mineral Products Co., Franklin

Carolina China Clay Co., Penland.
General Mica Co., Penland.
Penland Feldspar & Kaolin Co., Penland.
D. T. Vance, Plumtree.

Ohio.

Gilbert H. Downey, The Westlake, Cleveland.

Virginia.

F. G. Hoffman, Claremont.
Richmond Mica Co., Richmond.

Wisconsin.

W. E. Krause Co., 8136 Milwaukee Ave., Wauwatosa.

Punch or Circle

Illinois.

American Mica Products Co., 313 W. Chestnut St., Chicago.
United States Gypsum Co., Chicago.

Massachusetts.

Huse-Liberty Mica Co., 171 Camden St., Boston.

New Hampshire.

New Hampshire Mica & Mining Co,, Keene.

New York.

Brooklyn

Ford Radio & Mica Corporation, 832 4th Ave.
Industrial Mica Corporation, 730 64th St.
Reliance Mica Co., 342 39th St.

New York City

William Brand & Co., 276 4th Ave.
General Mineral Co., 96-104 Spring St.
Otto Gerdau Co., 533 Canal St.
Gillespie Rogers Pyatt Co., Inc., 80 John St.
Mica Insulator Co., 200 Varick St.
Minerals & Insulation Corporation, 135 Prince St.
Eugene Munsell & Co., 200 Varick St.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Soeldner-Heyman Co., Inc., 149 Church St.
Varlacoid Chemical Co., 116 Broad St.

North Carolina.

Asheville Mica Co., Biltmore.
Carolina China Clay Co., Penland.
Penland Feldspar & Kaolin Co., Penland.
Spruce Pine Mica Co., Inc., Spruce Pine.

Ohio.

Gilbert H. Downey, The Westlake, Cleveland.

Uncut Sheet or Block

Georgia.

Frank Smith, Cartersville.

Illinois.

American Mica Products Co., 313 W. Chestnut St., Chicago.
Robert K. Preston Mica Co., 53 W. Jackson St., Chicago.

Massachusetts.

Huse-Liberty Mica Co., 171 Camden St., Boston.
The Macallen Co., 61 Macallen St., Boston.

New Hampshire.

New Hampshire Mica & Mining Co., Keene.

New Jersey.

Colonial Mica Co., 26 Exchange Place, Jersey City.

New York.

Ford Radio & Mica Corporation, 832 4th Ave., Brooklyn.
Industrial Mica Corporation, 730 64th St., Brooklyn.

New York City

American Mica Works, 49 West St.
William Brand & Co., 276 4th Ave.
Brazilian Trading Co,, Inc., 377 4th Ave.

General Mineral Co., 96-104 Spring St.
Otto Gerdau Co., 533 Canal St.
Mica Insulator Co., 200 Varick St.
Minerals & Insulation Corporation, 135 Prince St.
Mitchell-Rand Manufacturing Co., 51 Murray St.
Eugene Munsell & Co., 200 Varick St.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Soeldner-Heyman Co., Inc., 149 Church St.
Varlacoid Chemical Co., 116 Broad St.

North Carolina.

Asheville Mica Co., Biltmore
Carolina China Clay Co., Penland.
Penland Feldspar & Kaolin Co., Penland.
Spruce Pine Mica Co., Inc., Spruce Pine.

Ohio.

Gilbert H. Downey, The Westlake, Cleveland.

Pennsylvania.

Rodale Manufacturing Co., Emaus.

Virginia.

F. G. Hoffman, Claremont.

Cut

Illinois.

Robert K. Preston Mica Co., 53 West Jackson St., Chicago.
United States Gypsum Co., Chicago.

New Hampshire.

New Hampshire Mica & Mining Co., Keene.

New Jersey.

Colonial Mica Co., 26 Exchange Place, Jersey City.

New York.

Brooklyn

Industrial Mica Corporation, 730 64th St.
Reliance Mica Co., 342 39th St.

New York City

American Mica Works, 49 West St.
William Brand & Co., 276 4th Ave.
Brazilian Trading Co., Inc., 377 4th Ave.
General Mineral Co., 96-104 Spring St.
Otto Gerdau Co., 533 Canal St.
Gillespie Rogers Pyatt Co., Inc., 80 John St.
Mica Insulator Co., 200 Varick St.
Minerals & Insulation Corporation, 135 Prince St.
Mitchell-Rand Manufacturing Co., 51 Murray St.
Eugene Munsell & Co., 200 Varick St.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Soeldner-Heyman Co., Inc., 149 Church St.
Varlacoid Chemical Co., 116 Broad St.

North Carolina.

Asheville Mica Co., Biltmore.

Ohio.

Gilbert H. Downey, The Westlake, Cleveland.

Pennsylvania.

Rodale Manufacturing Co., Emaus.

Virginia.

F. G. Hoffman, Claremont.

Wisconsin.

W. E. Krause Co., 8136 Milwaukee Ave., Wauwatosa.

Ground

Georgia.

Frank Smith, Cartersville.

Illinois.

A. Daigger & Co., 161 West Kinzie St., Chicago.
United States Gypsum Co., Chicago.
Amalgamated Roofing Co., 6600 Central Ave., Clearing.

Massachusetts.
Fisk Rubber Co., Chicopee Falls.

New York.
John A. Wiener, 81 West 7th St., Oswego.

New York City
American Cyanamid & Chemical Corporation, 30 Rockefeller Plaza.
Barclay Chemical Co., Inc., 75 "A" Varick St.
Stanley Doggett, Inc., 473 Canal St.
General Mineral Co., 96-104 Spring St.
Mica Insulator Co., 200 Varick St.
Minerals & Insulation Corporation, 135 Prince St.
William H. Scheel, Inc., Water & John Sts.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Wishnick-Tumpeer, Inc., 295 Madison Ave.,

North Carolina.
Asheville Mica Co., Biltmore.
Carolina China Clay Co., Penland.
General Mica Co., Penland.
Penland Feldspar & Kaolin Co., Penland.

Ohio.
Natl. Sales Corporation, 31-35 East 13th St., Cincinnati.
Gilbert H. Downey, The Westlake, Cleveland.
Harshaw Chemical Co., 1933 East 97th St., Cleveland.
Weaver Wall Co., Brookpark & State Roads, Cleveland.

Wisconsin.
W. E. Krause Co., 8136 Milwaukee Ave., Wauwatosa.

Splittings

Georgia.
Frank Smith, Cartersville.

Illinois.
Robert K. Preston Mica Co., 53 West Jackson St., Chicago.
United States Gypsum Co., Chicago.

Indiana.
Continental-Diamond Fibre Co., Valparaiso.

Massachusetts.
The Macallen Co., 61 Macallen St., Boston.
New England Mica Co., Waltham.

New Hampshire.
New Hampshire Mica & Mining Co., Keene.

New York.
Mica Company of Canada, Inc., Massena.

Brooklyn
Industrial Mica Corporation, 730 64th St.
Reliance Mica Co., 342 39th St.
American Mica Works, 49 West St.

New York City
William Brand & Co., 276 4th Ave.
General Mineral Co., 96-104 Spring St.
Otto Gerdau Co., 533 Canal St.
Gillespie Rogers Pyatt Co., Inc., 80 John St.
Mica Insulator Co., 200 Varick St.
Minerals & Insulation Corporation, 135 Prince St.
Eugene Munsell & Co., 200 Varick St.
A. O. Schoonmaker Insulation Co., Inc., 345 Hudson St.
Soeldner-Heyman Co., Inc., 149 Church St.
Varlacoid Chemical Co., 116 Broad St.

North Carolina.
Asheville Mica Co., Biltmore.
Penland Feldspar & Kaolin Co., Penland.
Tar Heel Mica Co., Plumtree.
D. T. Vance, Penland.

Ohio.
Gilbert H. Downey, The Westlake, Cleveland.

Wisconsin.
Allis-Chalmers Manufacturing Co., Milwaukee.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes of personnel in the Division of Mines to be noted in the past three months.

New Publications.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, October, 1937, being Chapter 4 of State Mineralogist's Report XXXIII. This Chapter contains: "Mineral Resources of the Resting Springs Region, Inyo Couty." "Paleozoic Section in the Nopah and Resting Springs Mountains, Inyo County." "Native Arsenic from Grass Valley, California"; also the complete Index for Volume XXXIII.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, January, 1938, being Chapter 1 of State Mineralogist's Report XXXIV. This Chapter contains: "Mineral Development and Mining Activity in Southern California during the year 1937." "Doing something about Earthquakes." "Gold and Petroleum in California." "Gem Minerals of California," and "Lapidary Art."

Commercial Mineral Notes (Nos. 178-180, inc.). February, March and April, 1938, respectively. These 'Notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to four pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

Henry H. Symons, Statistician and Curator

STATISTICS

The counties of California have produced for some years past more than 50 different mineral substances, the total value of which was estimated at $351,487,000 for 1937. See January, 1938, issue of the California Journal of Mines and Geology.

At present (April, 1938) reports for most of the producers are in hand. Data for several substances are now complete and have been compiled, being presented herein. Information at hand indicates that there was no commercial production during 1937 of the following: antimony, asbestos, bismuth, graphite, lithia, manganese ore, molybdenum ore, serpentine, shale oil, strontium, titanium, or tin.

There was a single producer of each of the following: bromine, fluorspar, magnesite, potash, pyrite, and wollastonite.

For the first time in this State, zircon sands appeared on the list of commercial producers. This came from a dragline dredge near Lincoln in Placer County, and was shipped for sand-blasting and experimenting in the manufacture of refractories.

BORATES

During 1937 there was produced in California a total of 346,487 tons of borate materials compared with 319,658 tons for the year 1936. The material shipped during the year included the new sodium borates, kernite (rasorite), Kramerite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County.

As the crude ore is not sold as such, but is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, and because of the fact that the material varied widely in boric acid content, we have recalculated the tonnage to a basis of 40 per cent A. B. A. This is approximately the average A. B. A. content of colemanite material after calcining, and also of the crystallized borax obtained from evaporation of the lake brines.

Recalculated as above, the 1937 production totaled 326,099 tons valued at $6,206,619. This was an increase both in quantity and value over the 1936 output, which was 313,389 tons worth $5,911,093.

The total amount of borates exported from the United States [1] during the year 1937 was 153,772 tons valued at $4,708,691, as compared with 102,021 tons worth $3,119,850 in 1936.

[1] Monthly Summary of Foreign Commerce of the United States, Department of Commerce, Dec., 1937.

CEMENT

During 1937 there was a production of 12,072,062 barrels of cement in California, valued at $16,546,229 f.o.b. plant, of which 4,339,320 barrels came from northern California plants, and 7,732,742 barrels came from southern California plants. The 1937 output was a decrease from that of 1936, which was 13,300,188 barrels worth $18,314,589.

Shipments during 1937 were made from ten plants in nine counties to the extent of 11,721,818 barrels valued at $16,868,379, as compared with 12,994,393 barrels worth $18,090,256. There were five plants in operation in northern California—one each in Calaveras, Contra Costa, Merced, San Mateo, Santa Cruz counties, which shipped 4,284,965 barrels of cement; and five plants in southern California, two in San Bernardino County, and one each in Kern, Los Angeles and Riverside counties, which shipped 7,436,853 barrels of cement. There were 2,157 men employed in the above plants during the year 1937.

CHROMITE

During the year 1937 there were shipments of chromite or chromic iron ore in California amounting to 1,918 short tons, recalculated to a basis of 45% Cr_2O_3, valued at $20,830 f.o.b. shipping point, and came from two properties in Del Norte County and one each in El Dorado, Fresno, Placer, Santa Barbara, and Tulare counties. The total shipments for 1937 were the largest since 1919. The 1936 output amounted to 221 tons worth $3,314.

Occurrence.

Chromite is widely distributed in California, the principal production, thus far, having come from El Dorado, San Luis Obispo, Del Norte, Shasta, Siskiyou, Placer, Fresno, and Tuolumne counties. In 1918 a total of 29 counties contributed to the State's output. There are two main belts in California yielding this mineral, one along the Coast Ranges from San Luis Obispo County to the Oregon line, including the Klamath Mountains at the north end, and the other in the Sierra Nevada from Tulare County to Plumas County. Chromite occurs as lenses in basic igneous rocks such as peridotite and pyroxenite, and in serpentines which have been derived by alteration of such basic rocks.

Imports.

Imports of foreign chromite[1] to the United States duty free during 1937, came mainly from Southern Rhodesia, Union of South Africa, New Caledonia, Philippine Islands, Turkey, Greece, and India. The total was 553,916 long tons, valued at $7,324,488 for 1937, compared with 324,258 long tons worth $4,431,898 for 1936.

DOLOMITE

The 1937 output of dolomite in California amounted to 12,371 short tons valued at $24,603. This came from four properties—one each in Inyo, Los Angeles, Monterey, and San Benito counties.

[1] Monthly Summary of Foreign Commerce of the United States. Department of Commerce, Dec., 1937.

The 1937 production showed a decrease in amount and value as compared with that of 1936, which was 25,807 tons, worth $63,122.

The material shipped was utilized for steel-furnace flux and refractories, plaster, stucco, dash-coat, terrazzo, art stone, for the manufacture of CO_2, and mineral wool.

FELDSPAR

The output of feldspar in California during 1937 amounted to 2686 short tons valued at $10,930 and came from two properties in San Diego County, and one in Fresno County.

The 1937 production was a decrease in quantity and value as compared with that of 1936 which was 3430 tons worth $24,959.

GYPSUM

During 1937 there were shipments of gypsum in California amounting to 186,160 tons valued at $384,431. This came from three properties in Fresno County, and one each in Imperial and Riverside counties. Shipments showed an increase in both amount and value over the 1936 output which was 143,549 tons worth $282,703.

IRON ORE

During 1937 shipments of iron ore were made in California coming from two properties each in Inyo and San Bernardino counties. These amounted to 5490 short tons valued at $29,340, as compared with 31,084 tons worth $155,434 for 1936.

The 1936 output came from two properties in San Bernardino County and one in Santa Cruz County. The material mined during the year was magnetite and hematite from Inyo County, and hematite from San Bernardino County. The hematite was used mostly in high iron cement with some going to foundries as a flux. The use to which the magnetite was put was not disclosed.

There was also some high grade limonite mined in Yuba County, but as it was used in the manufacture of pigments, it has been classed under Mineral Paints.

There are considerable deposits of iron ore known in California, notably in Shasta, Madera, Placer, Riverside, San Bernardino, and Los Angeles counties, but production has so far been limited for lack of an economic supply of coking coal. Some pig iron has been made, utilizing charcoal for fuel, both in blast furnaces and by electrical reduction; also, ferrochrome, ferromanganese, and ferrosilicon have been made in California.

MAGNESIUM SALTS

During 1937 there was an output of magnesium salts in California coming from one plant in San Diego County, and two in San Mateo County. This amounted to 3867 short tons valued at $316,669, and consisted of the chloride and carbonate. The 1936 output amounted to 3798 tons worth $347,838, which was also the chloride and the carbonate. The chloride was nearly all sold for use in magnesite stucco and cement mixtures (Sorel cement), also some for road liquor. The carbonate, a bulky white powder, was used as a heat-insulating material, as a filler for rubber, paper, paint, etc., and in medicines, in tooth paste,

in face powder and as a polish for metal and glass. The sulphate marketed in past years was utilized for medicinal and bath purposes. The material coming from San Diego County was residual bitterns from the salt plants and was in part marketed in the liquid form carrying from 35% to 67% $MgCl_2$ and in part as dry crystals, while that from San Mateo County was magnesium carbonate.

The average value reported for the chloride produced in California in 1937 was approximately $29.69 per ton, f. o. b. plant.

PUMICE and VOLCANIC ASH

The production of pumice and volcanic ash in California during the year 1937 amounted to 10,392 short tons, valued at $79,005. This came from five properties in Siskiyou County, four in Inyo County, two each in Madera and Napa counties; and one each in Imperial, Kern, Mariposa, Mono, and San Luis Obispo counties.

The 1937 figures showed a decrease in amount and value as compared with those of 1936 which were 17,132 tons worth $143,709.

The material from three deposits in Inyo County, part from Madera, and that from Imperial, Mariposa, Mono, Napa, and Siskiyou counties, was 6387 tons of lump pumpice, which was used in acoustic plaster, light-weight aggregate in concrete, for abrasive purposes, and for chicken-house litter. The production part of one property in Madera County, one property in Inyo, and that in Kern and San Luis Obispo counties was 4005 tons of volcanic ash, or tuff variety, and was employed in making soap, cleanser compounds, a large tonnage being utilized as a concrete filler in cement displacement, and in asphalt and as a carrier for dry agricultural sprays. The Kern County ash is going into the preparation of one of our popular and nationally advertised brands of cleanser compounds.

SILICA (Sand and Quartz)

We combine these materials because of the overlapping roles of vein quartz which is mined for use in glass making and as an abrasive, and that of silica sand which, although mainly utilized in glass manufacture, also serves as an abrasive. Both varieties are also utilized to some extent in fire-brick manufacture.

We do not include under this heading such forms of silica as: quartzite, sandstone, flint, tripoli, diatomaceous earth, nor the gem forms of 'rock crystal,' amethyst, and opal. Each of these has various industrial uses, which are treated under their own designations.

The production of silica in California during 1937 amounted to 84,313 short tons valued at $348,987 f.o.b. rail shipping point, and came from two properties in Contra Costa County and one each in Monterey, Riverside, and San Diego counties. The above was an increase in both amount and value over the output of 1936 which was 77,830 tons worth $310,278. The 1937 output consisted of 83,567 tons of glass sand and 746 tons of vein or boulder quartz.

The glass sand came from Contra Costa, Monterey, and Riverside counties. For making the higher grades of glass, deposits in Contra Costa County are replacing the sand imported from Belgium. Belgium sand has displaced local material in the manufacture of sodium silicate ('water glass'). There are various deposits of quartz in California

which could be utilized for glass making, but to date they have not been so used owing to the cost of grinding and the difficulty of preventing contamination by iron while grinding.

Silica sand has been produced in the following counties of the State: Alameda, Amador, Contra Costa, El Dorado, Imperial, Inyo, Los Angeles, Mariposa, Mono, Monterey, Orange, Placer, Riverside, San Diego, San Joaquin, and Tulare, the chief centers being Contra Costa, Amador, Monterey, and Los Angeles counties. The industry is of limited importance, so far, because of the fact that much of the available material is not of a grade which will produce first-class colorless glass; for such, it must be essentially iron-free. Even a fractional per cent of iron imparts a green color to the glass.

The Tariff Act of June 21, 1930, placed a duty on sand, containing 95 per cent or more of *Silica* and not more than six-tenths of 1 per cent of oxide of iron and suitable for use in the manufacture of glass, of $2 per ton.

SLATE

Slate was first produced in California in 1889. Up to and including 1910 such production was continuous, but since then it has been irregular. Large deposits of excellent quality are known in the State, especially in El Dorado, Calaveras, and Mariposa counties, but the demand has been light owing principally to competition of cheaper roofing materials.

The production of slate in California during 1937 amounted to 5036 short tons and 440 squares, having a total value of $32,572 f. o. b. quarry and came from properties in Calaveras, El Dorado, Los Angeles, Inyo, and Tuolumne counties.

The 1937 figures showed a decrease in both amount and value from those of 1936 which were 12,252 and 65 squares having a total value of $49,818. Practically all the slate was crushed and used for roofing granules. The slate shingles came from Calaveras County, and that from Los Angeles County and a small amount from El Dorado and Inyo counties was sold as flagstone.

SOAPSTONE and TALC

The total output of talc and soapstone in California during 1937 amounted to 29,657 short tons valued at $347,772. This was an increase in both quantity and value over the 1936 figures, which were 25,643 tons valued at $309,287. Of the 1937 production, 28,202 tons were high-grade talc from Inyo and San Bernardino counties, which material was utilized mainly in toilet powders, paint, paper, for rubber manufacture, and some in ceramics. The remainder of 1455 tons was soapstone and came from Butte, El Dorado, and Los Angeles counties.

The 'soapstone' grades were used mainly for ceramics and as a filler in roofing paper, part also in magnesite cement and foundry facing.

It is reported that California talc has replaced to some extent imported talc in the toilet trade on the basis of quality. The largest production of talc in the United States comes from Vermont and New York and of massive soapstone from Virginia.

During 1937 imports of talc steatite, etc., totaled 26,876 short tons valued at $472,819, as compared with 24,520 tons worth $456,667 during 1936, according to the United States Bureau of Foreign and Domestic Commerce.

The Tariff Act of 1930 places a duty on talc, steatite or soapstone and French chalk, crude or unground, of one-fourth of one cent per pound.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20834 ALTAITE ($PbTe$) with GALENA (PbS) and SPHALERITE (ZnS). From Hill Top Mining Co. property, 18 miles northeast of Las Cruces, New Mexico.
Donor: F. W. Meneray. February, 1938.

20835 JAMESONITE (Pb_2Sb_2S) on SPHALERITE (ZnS). From Chuisbaia, Roumania.
Donor: Hatfield Goudey. February, 1938.

20836 MASSICOT (PbO) Lead Oxide. From Rescue Mine, El Dorado County, California. Old specimen not numbered: donor not known.

20837 ALUNITE ($K_2Al_6(OH)_{12}(SO_4)_4$). A hydrous sulphate of aluminum and potash. From the Alunite Mine of the Mineral Products Corp., in the Marysvale Mining District, Piute County, Utah.
Donor: Jacob W. Young.

20838 GARNETS (Almandite). From Wrangell, Alaska. Old specimen not previously numbered: donor not known.

20839 LIMONITE ($2Fe_2O_3.3H_2O$). From extensive deposit. Assay, 48.44% Fe, 12.26% SiO_2, 0.012% S.
From Johe Ranch, near San Luis Obispo, California.
Donor: E. L. Raymond. March, 1938.

20840 Wire GOLD in quartz. From Green Ledge Mine, Genesee, Plumas County, California.
Donor: Louie Eddelbuttel. March, 1938.

20841 MANGANESE ORE, assays 57.57% Mn, and 4.30% SiO_2. From Staneuch Mine on Prefumo County Road, San Luis Obispo County, California.
Donor: Edward L. Raymond. March, 1938.

20842 CHROMITE, from Baker Chrome Mine, Quincy, Plumas County, California.
Donor: Louie Eddelbuttel. March, 1938.

20843 MANGANESE ORE. From Mt. Huff Mine, Quincy, Plumas County, California.
Donor: Louie Eddelbuttel. March, 1938.

20844 FLUORITE (CaF). Probably from Cumberland, England. Old specimen not numbered: donor not known.

20845 VANADINITE ($3Pb_3V_2O_8PbCb_2$). Large crystals. From Yuma Mine in Pima County, Arizona.
Donor: Herbert Salinger. March, 1938.

20846 VANADINITE Crystals on WULFENITE Crystal. From Yuma Mine in Pima County, Arizona.
Donor: Herbert Salinger. March, 1938.

20847 FLUORITE (CaF_2), calcium fluoride and CELESTITE ($SrSO_4$), strontium sulphate. From Clay Center, Ohio.
Donor: R. A. McMullen. March, 1938.

20848 SILVER ORE. From Easley Vein, 280-ft. level of Palisades Mine near Calistoga, Napa County, California. Mined in 1929.
Donor: Walter W. Bradley. March, 1938.

20849 SILVER ORE (Argentite Pyrargyrite and chalcopyrite). From 380-ft. level, Palisades Mine, near Calistoga, Napa County, California. Mined in 1929.
Donor: Walter W. Bradley. March, 1938.

20850 ALMANDITE, (iron aluminum Garnet) in mica schist. From Garnet Mt., on extreme lower left limit of Stikine River, near Wrangell, Alaska.
Donor: Walter G. Culver. April, 1938.

20851 Green TOURMALINE. This was associated with topaz, beryl topaz, quartz, epidote, and some lithia mica. From near Ramona, San Diego County, California.
Loaned by Mr. McIntosh.

20852 GOLD ORE. From Monumental Mine, Del Norte County, California.
Donor: H. C. Kirkpatrick. April, 1938.

20853 Blue CALCITE on Idocrase. From North Fork of Shepard Canyon, Inyo County, California; one-half mile north of Crystal Dome Mine.
Donor: E. A. Bacchi. April, 1938.

LABORATORY

Frank Sanborn, Mineral Technologist

An interesting mineral was recently received and identified as troilite by the laboratory of the Division of Mines. The mineral was brought in for determination by H. W. Gooch of Crescent City, Del Norte County, who has done considerable prospecting in that locality.

Troilite is a ferrous sulphide, FeS. It has the following properties: Hexagonal. Compact granular. Metallic luster. Color, light grayish-brown. Speedily tarnishes to bronze-brown. Streak black. H–3½–4½. G–4.67–4.82. It was first noted from this locality and analyzed in 1922.

	Fe	S
1	58.78	33.62
2	62.70	35.40

This is its only known terrestrial occurrence. It had been observed previously only in meteorites. It was found in serpentine and contained inclusions of magnetite from which it has probably been derived.

This mineral has no commercial value outside of its specimen value to mineral collectors, who are invited to communicate with Mr. Gooch who can supply specimens at reasonable prices.

It is our policy to give assistance to prospectors in identifying and finding a market for minerals found in California, and to have the operators and prospectors of the state make use of the laboratory for that purpose.

LIBRARY

J. C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE ESPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Bureau of Mines:

Technical Paper No. 581, Ball Mill Grinding.
Bulletin No. 410, Metal—Mine Accidents in the U. S. 1935.

Information Circulars:

6983 Some Pertinent Information about Mine Gases.
6984 Mineral Wool. By J. R. Thoenen.
6985 Gold Mining & Milling Methods and Costs at The Gold Hill Mine of Talache Mines, Inc., Quartzburg, Idaho. By Joe H. Skidmore.
6987 Gold Mining in New Mexico. By O. H. Metzger.
6988 Trends in Sales of Memorial Stone. By Oliver Bowles and Mabel Schauble.
6989 Methods for Protection Against Silicosis and When They are Justified. By D. Harrington.
6991 Gold Mining and Milling in the Wickenburg Area, Maricopa and Yavapai Counties, Arizona. By O. H. Metzger.
6993 Technique for Routine Use of the Konimeter. By J. B. Littlefield, C. E. Brown and H. H. Schrenk.
6994 Some of the Results of Recent Research on the Control or Prevention of Silicosis. By D. Harrington.
6995 Reconnaissance of Mining Districts in Humboldt Co., Nevada. By William O. Vanderburg

6996 The Bureau of Mines and Mineral Utilization. By John W. Finch.
6997 Marketing Mica. By Paul M. Tyler.
6998 Marketing Clay. By Paul M. Tyler.
6999 Laboratories that make assays, analyses and tests on ores, minerals, and other substances. By C. W. Davis and M. W. Von Bernewitz.
7000 Treatment and Sale of Black Sands. By M. W. Von Bernewitz.
7001 Review of Literature on Conditioning Air for Advancement of Health and Safety in Mines. By D. Harrington and Sara J. Davenport.
7002 Mine Safety Board Decision 28; Safety Catches and Arresting Devices for Cages, Skips, and Cars in Mine Shafts and Slopes. By Mine Safety Board.
7003 Mining Methods and Costs at the Judge Mine, Park City, Utah. By Geo. S. Krueger and E. A. Hewitt.
6611R Federal Placer-Mining Laws and Regulations. By Fred W. Johnson, Commissioner of General Land Office.
Small-Scale Placer Mining and Methods. By Chas. J. Jackson.

Report of Investigations:

3367 Survey of Fuel Consumption at Refineries in 1936. By U. S. Bureau of Mines.
3368 Petrographic Identification of Atmospheric Dust Particles. By Wilder D. Foster and H. H. Schrenk.
3369 Relation of Dust Concentration to Depth of Hole During Wet Drilling. By J. B. Littlefield and H. H. Schrenk.
3370 Progress Reports—Metallurgical Division 22: Ore-testing Studies, 1936-1937 (Special Methods of Analysis and Testing and Details of Tests on Various Ores. The Staff of the Ore-Testing Section.
3371 Performance of a Baum-Type Coal-Washing Jig. By H. F. Yancey and M. R. Geer.
3372 Performance of a Pulsator-Type Coal-Washing Jig. By H. F. Yancey, M. R. Geer, and R. E. Shinkoskey.
3376 Concentration of Southern Barite Ores. By G. O'Meara and G. D. Coe.
3377 Primary Crushing, Progress Report No. 1. By Mark Sheppard and C. N. Witherow.
3380 Primary Crushing Progress Report No. 2. By Mark Sheppard.
3381 Effect of Angle of Drilling on Dust Dissemination. By Carlton E. Brown and H. H. Schrenk.
3383 Annual Report of the Explosives Division Fiscal Year 1937. By Wilbert J. Huff.
3387 Dust Sampling With the Bureau of Mines Midget Impinger, Using a New Hand Operated Pump. By J. B. Littlefield and H. H. Schrenk.
3388 Control of Dust from Blasting by a Spray of Water Mist. By Carlton E. Brown and H. H. Schrenk.
3390 Primary Crushing Progress Report No. 3. By. Mark Sheppard.
3392 Resumé of Problems Relating to Edgewater Encroachment in Oil Sands. By F. G. Miller and H. C. Miller.
3393 Relation of Dust Dissemination to Water Flow Through Rock Drills. By Carlton E. Brown and H. H. Schrenk.
3394 Disposal of Petroleum Wastes on Oil-Producing Properties. With a Chapter on Soils and Water Resources of Kansas Oil Areas. By Ogden S. Jones. By Ludwig Schmidt and C. J. Wilhelm.
3396 Calibration of Positive-Displacement Oil Meters. By R. E. Heithecker and W. B. Berwald.

U. S. Geological Survey:

Bulletin 892 Bibliography of North American Geology, 1935 and 1936.
Topographic Maps
Bidwell Bar Quadrangle.
Black Mountain Quadrangle ---------------------------Los Angeles County
Kettleman City Quadrangle ------------------------------Kings County
Manzana Quadrangle --------------------------------Los Angeles County
Medford Quadrangle ---------------------------------Oregon-California
San Francisquito Quadrangle--------------------------Los Angeles County
Ventura Quadrangle
Yosemite Quadrangle

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers. New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California, Magazine of the Pacific, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.

Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Moscow, Idaho.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Industry, Los Angeles.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.

Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

Oil Field Maps, published by Pacific Coast Edition of the Wall Street Journal:

Los Angeles Basin Oil Fields Map "E."
Master Map of California Oil Fields.
Northern Coastal District Oil Fields Map "B."
San Joaquin Valley Oil Fields Map "A."
Ventura County Oil Fields, Map "D."

Books:

Annual Report of the Chief of Engineers, U. S. Army, Part 1, 1937.
Annual Report of the Chief of Engineers, U. S. Army, Part 2, 1937.
Industrial Minerals and Rocks, Seeley W. Mudd Series, A. I. M. E., 1937.
Theory and Practice of Mine Ventilation, by W. J. Montgomery.
The Condensed Chemical Dictionary, 2d Edition.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

PRICES SUBJECT TO CHANGE. WRITE FOR LATEST PRICE LIST

	Price Postpaid
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	$0.75
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	.75
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	---- 1.15
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	1.50
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report XIV, Biennial Period, 1913-1914, Fletcher Hamilton:	
Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	.60
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.75
Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	.35
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	.50
Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	.60
Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915:	
A General report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	3.25
Chapters of the State Mineralogist's Report XV, Biennial Period, 1915-1916 Fletcher Hamilton:	
Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	.75
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.75
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	$0.75
Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	.60
Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	.75
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper	1.00
Mines and Mineral Resources of Plumas County, 188 pp., paper	.75
Mines and Mineral Resources of Sierra County, 144 pp., paper	.75
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	2.50
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, November, December, 1922	.40
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	.40
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, October, 1924, per copy, 30¢; July, per copy	.40
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.40
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.40
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.40
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.40
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California', Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.40
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.40
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.40
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.40
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.40
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County	.40
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.40

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
April, 1928, Mines and Mineral Resources of Mariposa County	$0.40
July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	.40
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.40
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.40
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.40
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.40
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.40
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.40
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	.40
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	.40
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradlley. Published quarterly:	
January, 1931, Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete	.40
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island	.40
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931	.40
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.40
April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	.40
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)	.25
July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a Part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Chapters of Report XXIX, 1933 (quarterly: titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic Map showing various mines and prospects of part of Del Norte and Siskiyou Counties	$1.00
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming. Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543	1.00
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits	.60
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**Map of California, Showing Mineral Deposits (50x60 in.)	----
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**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
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**Map of Shasta County, Showing Boundaries, National Forests	----
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Map No. 6—Salt Lake-Beverly Hills, Los Angeles County	1.25
Map No. 7—Sunset and San Emidio, Kern County	1.25
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DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

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OF

MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXIV

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

62700

DIVISION OF MINES

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State Mineralogist

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PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geological Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire State of a given mineral substance, e.g. feldspar).

3. Geological reports on specific areas (recording results and conclusions, with maps, derived from field studies; and tied in with economic possibilities, and developments).

A slate worker making roofing slate. El Dorado County has several good deposits suitable for roofing.

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District, on account of unfinished field work.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

Reports covering the mines and mineral resources of most of the counties in the Los Angeles field district are now available, and field work at present is confined to investigations for special reports upon Inyo and Mono counties.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

MINERAL RESOURCES OF EL DORADO COUNTY [1]

History.

Coloma, scene of James W. Marshall's epochal gold discovery January 24, 1848, is on the South Fork of American River eight miles northwest of Placerville. Spreading out in all directions from this focal point to which they had been drawn by the exciting news, thousands of miners occupied the shallow placers in this and nearby counties on the western slopes of the Sierra Nevada. In El Dorado they found gold in nearly every stream as far east as Grizzly Flat. Quartz mining began on the Mother Lode in this county in 1851 at the Havilah Mine, Nashville, and for years many arrastres were used at that camp and at the Union Mine at Aurum City farther north on the lode, to crush rich ore found on and near the surface. In 1851 also, the Mt. Pleasant and Sierra Nevada Mines were opened at Grizzly Flat. The county was the most populous in the state up to 1853. It enjoyed great prosperity during the Comstock boom because of the traffic with the Nevada mines over the Placerville wagon road, extending for 82 miles from the railroad terminus at Shingle Springs, over the Sierra Nevada to Carson Valley.

The county was particularly noted for its placers and pocket mines. The seam mines, which are not peculiar to the county, but which have been worked there more extensively than elsewhere, also contributed heavily in gold production. However, the quartz mines did not share in the extensive and deep development carried on in other counties and it is only since the revival of the industry in the past four years that work has gone to depths of over 1200 ft.

Plant of Pacific Minerals Co., Limited, at Chili Bar on South Fork of American River. Roofing granules are made here from Mariposa slate taken from a deposit adjoining the plant.

[1] See pp. 363, *et seq.*, for additional data on El Dorado County mines.

From the early 1860's, El Dorado County was famous for its fruit industry, and specializes at present in pear-raising. Lumbering has been an important business since pioneer days. The population of the county in 1930 numbered 8300, living mostly in the vicinity of the county-seat and in or near the small towns extending from Georgetown on the north, along the Mother Lode to Nashville. This number represented an increase of nearly 2000 since 1920, and there has probably been at least as great an increase due to the revival of gold mining since 1932.

Ranging in elevation from 500 feet above sea-level where it joins Sacramento County on the west, to 10,000 feet on the higher peaks of the Sierra Nevada, the county shares a great variation of climate and scenery with its neighbors. Rainfall increases with elevation, averaging 43 inches annually over a period of about 50 years at Placerville, the county-seat, (elevation 1860 ft.). Usually little snow falls below this elevation, and the dry season extends from May to November.

The Mother Lode and western sections of the county are supplied with electric power and good roads, and water may generally be purchased for mine use. The eastern section supplies an abundance of good pine timber, with sawmills at several convenient points.

ASBESTOS

Between 1904 and 1906, a total production of 142 tons of asbestos was reported from this county. Part of this came from the El Dorado Copper Company's property in sec. 24, T. 12 N., R. 10 E., and the French Hill claim in sec. 36, T. 13 N., R. 9 E., was also listed as an asbestos property, but there are no details of its output available. There is no record of any later activity in prospecting for asbestos.

Serpentine areas, in which chrysotile asbestos might occur extend north and south for 6 miles in the region 2 miles east of Georgetown. The rock is also found in a line of disconnected outcrops extending from Cosumnes River northwest past Latrobe, thence east of Clarkville and west of Salmon Falls to the Middle Fork of American River. Practically all of this land is patented and is used for cattle range. Chromite has been mined on most of it, but no asbestos has been reported from it.

CHROMITE

During the world war this county was one of the principal producers of chromite ore and concentrate. Several mills had been erected and were in operation in the district south of Rattlesnake Bridge between the forks of American River, when the war ended. Only one producer, Placer Chrome Company, continued work after the price collapsed. They operated near Rattlesnake Bar until the end of 1920. Except for the shipment in 1931 of a little ore mined previously, there has been no record of activity until the past few years. From what can be learned, a promoter named Bedford had sold shares in England several years ago in a company which was to use chromite from El Dorado County in the plant of Darlington Rustless Iron Company, in County Durham. Bedford's options on the local chromite deposits expired without any ore having been produced. Late in 1935, A. H. Wild, an Englishman who represented himself as

Year	Gold, value	Silver, value	Copper		Lime	
			Pounds	Value	Barrels	Value
1880	$389,383	$208				
1881	550,000	900				
1882	600,000					
1883	530,000					
1884	575,000	16,000				
1885	35,000					
1886	619,992	1,822				
1887	706,871	365				
1888	650,000	500				
1889	427,638	408				
1890	204,583	275				
1891	173,279	359				
1892	198,321					
1893	294,610	1,220				
1894	366,707	356			10,000	$8,000
1895	700,101	448			28,500	28,500
1896	812,289	534			4,413	4,158
1897	674,626	886			13,500	6,750
1898	501,966	4,174			3,360	3,360
1899	404,497	8,414			7,935	7,935
1900	368,541	25,129	3,125	$500	7,500	6,000
1901	292,036	5,977			11,000	11,000
1902	335,031	52	2,128	319	24,599	16,176
1903	277,304				5,600	7,000
1904	474,994				12,864	7,075
1905	384,735	2,525	160,000	24,960	9,260	6,946
1906	431,746	2,690			19,217	21,138
1907	319,177	2,301		122		16,198
1908	342,033	5,504	603	83	15,921	20,192
1909	238,284	1,299			13,828	14,591
1910	171,304	967			11,300	9,944
1911	133,967	1,010			15,086	12,309
1912	105,565	843			14,023	11,218
1913	62,688	250	693	107		
1914	133,886	654			14,000	12,082
1915	401,288	1,353	417	73	15,911	12,872
1916	361,821	1,496	[3]		[3]	
1917	24,758	85	18,982	5,182	[3]	
1918	28,352	722	22,259	5,498		
1919	30,121	279				
1920	13,379	155				
1921	34,109	301				
1922	47,340	376				
1923	30,264	185				
1924	28,207	153				
1925	40,212	238				
1926	91,789	472			[3]	
1927	82,254	383	[3]			
1928	122,017	697	1,074	155		
1929	57,680	236	[3]		[3]	
1930	78,019	250			[3]	
1931	85,322	283	[3]		[3]	
1932	182,043	438	850	54	[3]	

COUNTY, 1880-1937.

Limestone		Slate		Miscellaneous stone[2], value	Miscellaneous and unapportioned		
Tons	Value	Squares	Value		Amount	Value	Substance
[1]	----	----	----	----	----	----	
----	----	----	----	----	----	----	
----	----	----	----	----	----	----	
----	----	----	----	----	----	----	
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----	----	----	----	----	----	----	
----	----	----	----	----	----	----	
----	----	----	----	----	----	----	
----	----	1,800	$11,700	----	----	----	
----	----	1,350	9,450	----	----	----	
----	----	500	2,500	----	----	----	
500	$250	400	2,800	----	----	----	
----	----	400	2,800	----	----	----	
----	----	600	4,500	----	----	----	
----	----	3,500	26,250	----	----	$251,820	Unapportioned, 1900-09.
----	----	5,100	38,250	----	----	----	
----	----	4,000	30,000	----	----	----	
----	----	----	----	----	----	----	
----	----	6,000	50,000	----	10 tons	162	Asbestos.
1,050	5,775	4,000	40,000	----	112 tons	2,625	Asbestos.
----	----	10,000	100,000	----	20 tons	1,000	Asbestos.
----	15,318	7,000	60,000	----	----	----	
----	----	6,000	50,000	$1,600	200 M	8,000	Paving blocks.
----	----	6,961	45,660	530	3,763 tons	5,645	Sand (glass)
----	----	1,000	8,000	2,616	1,200 tons	1,800	Sand (glass)
1,000	1,000	----	----	5,465	3,701 lbs.	167	Lead.
----	----	----	----	4,375	----	----	
----	----	----	----	4,678	----	----	
----	----	----	----	2,600	90 lbs.	4	Lead.
----	----	[3]	----	7,500	----	5,250	Slate and soapstone.
					5,260 tons	72,560	Chromite.
					----	19,613	Lime and limestone.
[3]	----	----	----	12,000	886 tons	1,717	Silica.
					----	1,480	Copper and soapstone.
					8,319 tons	167,950	Chromite.
					----	104,851	Lime and limestone.
[3]	----	----	----	6,200	2,684 tons	4,506	Silica.
					----	70	Other minerals.
96,673	218,120	----	----	20,500	11,936 tons	674,856	Chromite.
					----	11,236	Pyrites, silica, soapstone.
					378 tons	6,510	Chromite.
41,025	112,423	----	----	1,700	1,600 tons	13,950	Soapstone and talc.
					----	1,169	Other minerals.
41,109	139,873	----	----	5,500	2,640 tons	18,200	Soapstone.
					----	9,325	Other minerals.
15,296	66,143	----	----	2,750	1,652 tons	9,453	Talc.
42,200	113,700	----	----	4,250	----	18,850	Slate and soapstone.
95,274	163,987	----	----	5,900	2,670 tons	15,729	Soapstone.
112,156	322,995	----	----	2,538	1,498 tons	8,988	Talc.
					----	32,691	Copper and lime.
228,293	297,127	----	----	10,305	----	4,946	Lime and silica.
59,386	186,702	[3]	----	17,510	----	5,613	Lime, silica, slate.
96,733	146,506	[3]	----	500	----	15,792	Copper, gems, silica, soapstone, slate.
57,012	158,252	[3]	----	17,455	365 tons	8,855 21,995	Soapstone, lead, silica, slate.
71,033	199,989	[3]	----	25,665	----	83,930	Copper, lime, silica, slate, soapstone.
88,869	205,225	[3]	----	96,599	----	113,105	Lead, lime, silica, slate, soapstone.
79,798	207,594	[3]	----	37,494	----	107,242	Chromite, copper, lead, lime, silica, slate, soapstone.
105,094	207,241	[3]	----	----	----	97,126	Lead, lime, platinum, silica, slate, miscellaneous stone, soapstone, tungsten ore.

EL DORADO COUNTY.

Year	Gold, value	Silver, value	Copper		Lime	
			Pounds	Value	Barrels	Value
1933	$540,939	$1,458	2,755	$176	[3]	----
1934	1,380,710	6,035	4,312	345	8,250	$85,938
1935	1,803,368	5,943	12,391	1,028	[3]	----
1936	1,988,735	9,063	21,661	1,993	[3]	----
1937	1,719,795	8,238	65,353	7,908	[3]	[3]
Totals	----	----	----	----	----	----

1880-1937—Continued

Limestone		Slate		Miscellaneous stone[2], value	Miscellaneous and unapportioned		
Tons	Value	Squares	Value		Amount	Value	Substance
120,026	$208,049	[3]	------------	$7,551	------------	$90,586	Lead, lime, slate, soapstone.
112,237	152,422	[3]	------------	7,400	------------	18,405	Lead, silica (quartz), soapstone, slate.
151,814	298,867	[3]	------------	46,886	------------	232,907	Lead, lime, mineral water, silica (quartz), slate, soapstone.
159,134	348,055	[3]	------------	77,778	------------	371,356	Chromite, lead, lime, mineral water, platinum, slate, soapstone.
227,721	448,130	[3]	------------	20,784	[3]	402,762	Chromite, lime, mineral water, platinum, slate, soapstone.
----------	----------	----------	----------	----------	----------	----------	

a stockholder in the above venture and a principal owner of the old Darlington plant, took options on many of the old chromite mines, including the Pilliken, Steele, Placer Chrome, and others. During 1936 and 1937, under the name of United States Chrome Mines, Inc., a small experimental plant for concentrating chromite was operated intermittently, and Wild reported a shipment of concentrate by water to the eastern seaboard early in 1937. When visited August 13, 1937, the equipment, which was 3½ miles south of the Auburn Chemical Lime Company's plant, had been mostly dismantled and was scattered over the hillside. No one was on the ground. Work has been resumed recently.

Old chromite workings on the Pilliken property showing how good ore occurred in scattered bodies. Mining has recently been resumed in this district.
(Photo by C. A. Waring)

The chromite mining operations of past years in this county were described in our Bulletin 76, pages 131-144, to which the reader should refer for further details.

COPPER

The western belt of copper prospects extends from Latrobe and Cothrin to the vicinity of Cool. Most of these deposits are either sulphide impregnations or replacements of the amphibolite schist country rock, or quartz veins carrying sulphides. East of the Mother Lode, copper ore occurs in places near the contact of granodiorite and limestone and other rocks of the Calaveras formation, as at the Cosumnes Copper Mine, five miles southwest of Grizzly Flat. It has also been found in similar associations around the peripheries of granodiorite areas west of the Mother Lode. Prospects have been noticed also near or in serpentine areas east of Georgetown. Although some small mines were productive along the west belt between 1860 and 1870, no record of their output remains. In 1905, about 160,000 lbs. of copper was produced in the county and in 1917 and 1918 a total output of 41,000

lbs. was reported. Since then, only a few hundred to a few thousand pounds of copper has been produced annually as a by-product of gold quartz mining.

The following table gives the location of copper prospects and references to our reports which the reader may consult for further details.

Table of Copper Prospects in El Dorado County

	Location			
Name	*Section*	*Twp.*	*Range*	*Latest report*
Agara	19	8 N.	9 E.	Bull. 50, p. 216
Alabaster Cave	10, 15	11 N.	8 E.	Bull. 50, p. 211; XV, p. 276
Arizona	24	12 N.	10 E.	Bull. 50, p. 214
Big Buzzard	29	11 N.	8 E.	R. XIX, p. 141, R. XXII, p. 406
Bob	13	12 N.	10 E.	Bull. 50, p. 219
Boston	22	9 N.	9 E.	Bull. 50, p. 216
Breala	2	8 N.	9 E.	R. XXII, p. 407
Bunker Hill	14	12 N.	9 E.	Bull. 50, p. 219
Cambrian	23	11 N.	9 E.	Bull. 50, p. 213
Camel Back	11	11 N.	8 E.	R. XVII, p. 430, R. XXII, p. 407
Contraband	24	12 N.	10 E.	Bull. 50, p. 214
Copper Chief	--	12 N.	10 E.	Bull. 50, p. 216
Costa Ranch	12	11 N.	8 E.	Bull. 50, p. 218
Cothrin	29	9 N.	9 E.	R. XXII, p. 407
Cosumnes	24, 25	9 N.	12 E.	Bull. 50, p. 218
Dr. Wren	7	9 N.	11 E.	Bull. 50, p. 216
E. E.	18	9 N.	11 E.	R. XV, p. 277
Hale	25	9 N.	12 E.	R. XV, p. 217
Irland	15	10 N.	10 E.	R. XV, p. 218
Larkin	29	10 N.	11 E.	R. XV, p. 277
Little Emma	3	11 N.	9 E.	Bull. 50, p. 212, R. XXII, p. 408
Noonday	18	9 N.	11 E.	R. XV, p. 278
Pioneer	3	11 N.	9 E.	Bull. 50, p. 213
Revoir	12	9 N.	12 E.	Bull. 50, p. 217
Rip and Tear	3	8 N.	9 E.	R. XXII, p. 408
Robert	13	9 N.	11 E.	Bull. 50, p. 216
Seven Bells or Sporting Boy	4 miles west of Placerville			R. XXII, p. 408
Voss	See Camel Back			

Gems, Jewelers Materials and Ornamental Stones

The occurrences of precious, semi-precious and ornamental minerals so far reported from the county are briefly alluded to, principally for the convenience of the increasing number of amateur mineral collectors.

Adularia—reported in the county, but no localities are given. This is a clear variety of orthoclase, to be found in granitic rocks, and large crystals are to be expected only occasionally where conditions were favorable.

Agalmatolite—(also called Pagodite or figure-stone because it has been used by the Chinese for carving miniature pagodas and other ornaments) is a name applied to some compact varieties of mica, pyrophyllite and steatite, according to Kunz. Reported 2 miles west of Greenwood.

Axinite, a borosilicate of aluminum and calcium, with iron and manganese. The color varies from white or yellow to dark brown or blue. Reported at the old Cosumnes copper mine on the Middle Fork of Cosumnes River 3 miles northeast of Fairplay, in small brown crystals on epidote.

Azurite—blue carbonate of copper. It has been found in the copper mines (which see) near the surface, but good specimens are becoming scarce.

Bornite—"horse-flesh copper ore" or "peacock ore." A sulphide of copper and iron usually occurring with chalcopyrite. A polished specimen of purple bornite and brassy-yellow chalcopyrite is showy. Found at several of the idle copper prospects. (See Copper, *ante*).

Brookite and *Octahedrite* have been found on quartz crystals at Placerville, and *octahedrite* has been taken from a locality 1 mile northeast of American Flat.

Californite—(See Idocrase)

Chalcedony—None of the colored varieties of this cryptocrystalline form of silica have been reported from the county. The white, translucent mammilary phase may be found occasionally in thin layers in the serpentine areas.

Chloropal (Nontronite)—Only an alteration of this mineral to limonite has been found, near Georgetown.

Diamond—A number of discoveries of diamonds were reported during the early period of placer mining around Placerville. Some of these discoveries prior to 1880 were mentioned by Goodyear[1] as quoted by Whitney. Two placer mining claims on the south side of Webber Hill, and one at Dirty Flat, both near Placerville, and mines at and near White Rock Canyon, 2½ to 3 miles northeast of that town, had yielded diamonds, one probably weighing "not far from one and a half carats." Smiths Flat was also said to have produced them. In all, about 60 diamonds are credited to the gold placer gravels of the county. All have been chance finds and probably a much greater number have been lost, as no one appears to have taken any special pains to use apparatus suited to saving them. No authentic discovery of a diamond in place, or of a rock matrix identical with that in which diamonds occur elsewhere, has yet been made in California. Many of the California diamonds are slightly 'off-color.'

Diopside, $CaMg(SiO_3)_2$ varies from white to deep grass green in color. Green crystals are found at the old Cosumnes copper mine and have also been reported "near Mud Springs."

Good crystals of *epidote* and *grossularite* have been found at the Cosumnes copper mine.

Gold in crystalized form suitable for jewelry or for collections, is often found in the 'seam diggings' and 'pocket' mines between Placerville and Georgetown. Crystallized specimens have been sold for more than the bullion value. A very fine specimen, 101.4 oz. troy weight, came from the Grit claim at Spanish Dry Diggins in 1865.

Idocrase (Vesuvianite). The green variety called *Californite* is found on Traverse Creek 2½ miles south of Georgetown in crystal form. White idocrase is also reported in the same locality.

[1] Whitney, J. D. The Auriferous Gravels of the Sierra Nevada of California. 1880. University Press, Cambridge, Mass.

Malachite (see Azurite).

Rock Crystal in large sizes, some weighing as much as 90 pounds was found in a vein at Placerville in 1891. Crystals have also been found in White Rock Canyon 4½ miles by road northeast of Placerville.

GOLD

There is probably no area in the state similar in size to western El Dorado County which contains such a number or variety of gold 'prospects.' While the scale of operations has not generally equalled that in some other counties, there have been numerous mines in operation lately that have yielded good ore. Adding to this the gold from many pocket, seam and small placer mines, the total output has been increased in recent years until the county has resumed its position as an important gold producer. From the low figure of only $13,379 production recorded for 1920, gold yield increased to $182,043 in 1932, and reached $1,988,735 in 1936. The Big Canyon, Montezuma, Beebe and Sliger mines have been the most important producers and the Gold Reserve and Black Oak, the last named a rich small mine, have added very materially to the total.

The Mother Lode traverses the entire length of the county and the deposits along its course vary greatly in character. In the southern part from the Amador County line to and including the Church Union mine, the veins occur in the Mariposa slate area and share many geologic features with the mines in this slate in Amador County. The slate belt is comparitively narrow and is flanked on the west, and for some distance on the east, by greenstones. Topographically the lode here occupies the narrow stream valley of the North Fork of Cosumnes River.

Near the Church Union, a granitic intrusive has entered the footwall of the slate, which changes its course to northeast and becomes much wider. From there north, gold is found not only in the slate but also in the intruded or interbedded igneous rocks. These rocks vary in character from granitic to ultra-basic, the latter having yielded serpentine. There are quartz veins in slate and schist, impregnations, dolomitic veins, pockets and seam deposits.

The 'seam diggings' extend from Placerville into Placer County. The gold in them occurs in quartz veinlets and seams in the decomposed schist of the greenstone rocks and in the slate. The soft, rotten upper parts of these deposits were worked extensively years ago by hydraulicking. Beginning near Garden Valley, a large body of amphibolite separates the Mariposa slate into two branches, one of which extends north through Georgetown and the once highly productive 'seam diggings' of Georgia Slide; the other striking northwest through Greenwood and Spanish Dry Diggins. The Alpine and Rozecrans mines are in the amphibolite schist mentioned and the Black Oak is at its extreme southern tip.

Among miners, the region east of the Mother Lode from Mariposa through El Dorado is called the East Belt. The metamorphic rocks of the Calaveras (Carboniferous) and exposed sections of the Sierra Nevada grantitic batholith occupy that section. They carry veins

which are generally narrower and may be richer in gold than the veins of the Mother Lode. The ore shoots are also likely to be smaller and the ores more complex, containing several sulphides such as galena, zincblende, chalcopyrite, pyrrhotite and arsenopyrite in considerable amount. The mines at Grizzly Flat in the granodiorite, and the Grand Victory mine in the Calaveras formation are examples of such mines.

Several good mines lie on the west side of the Mother Lode in the areas mapped as amphibolite schist, or near the outer boundaries of bodies of granitic rocks. In the former, feldspar and quartz are gangue minerals, and pyrite often carries most of the gold. The percentage of pyrite is rather high in these ores and the gold is so fine and so intimately associated with the pyrite that little of it can be amalgamated. Concentration by gravity or flotation processes, followed by smelting or cyanidation, are required. The Big Canyon, Gold Reserve and Crystal are examples of these mines.

Alhambra Mine. In S½ sec. 6 and N½ sec. 7, T. 11 N., R. 11 E., 2 miles by road northeast of Poor's Store. It was located in 1883 and a shaft was sunk 29 ft. A block of ground 23 ft. long is said to have yielded $27,600. Again in 1886 work was resumed and a depth of 64½ ft. was reached, with good ore reported. In 1934, Jensen and Schneider took a lease on the claim and at a depth of 90 ft. struck 'high grade' ore in a drift only a few feet from the old shaft. The initial 'strike,' made after 79 days' work, yielded over $10,000 in bullion which brought $30.50 an ounce at the mint. This was recovered by mortaring the rock and roasting some of the gold-bearing arsenopyrite. Later a similar amount was found. The claim passed into other hands and at present is being prospected by Alhambra Shumway Mining Company, Helm Building, Fresno, Calif. No substantial production has been made recently.

The gold occurs free and associated with arsenopyrite in lenses or nodules of quartz and calcite. These nodules are between layers of a very slippery, talc schist which forms the hanging wall. The footwall is gneiss. The strike is S.40°E. and the dip varies from nearly flat to 37° NE.

The present company has sunk a new shaft 130 ft. deep alongside the last of the older shafts. The 90-ft. level has been run 95 ft. southeast and 30 ft. west; the drift on the 130-ft. level extends 95 ft. southeast and 65 ft. northwest.

The equipment includes a single-drum hoist, air compressor and blower, all operated by electric motors and housed in a new building. There has never been any mill on this property. Three men are employed. Besides the Alhambra patented claim, 3 unpatented locations are owned.

Avansino Mine. Mineral rights under NE¼ sec. 29, T. 10 N., R. 12 E., in Pleasant Valley district. Gold-bearing gravel was found in 1893 under the Avansino and Fink ranches. If any production was made, it was not mentioned in available records. There is a shaft 107 ft. deep from which drifts have been run 57 ft. north on the 90-ft level, and 307 ft. south on 107-ft. level. The shaft is reported to pass through alternate layers of lava ash, sand and gravel. On the

90-ft. level a layer of gravel 42 ft. wide lies on a bench sloping toward the shaft, and a winze 20 ft. deep from the south end of the 107-ft. level is claimed to give prospects.

The workings were unwatered a few years ago but no new discoveries were reported.

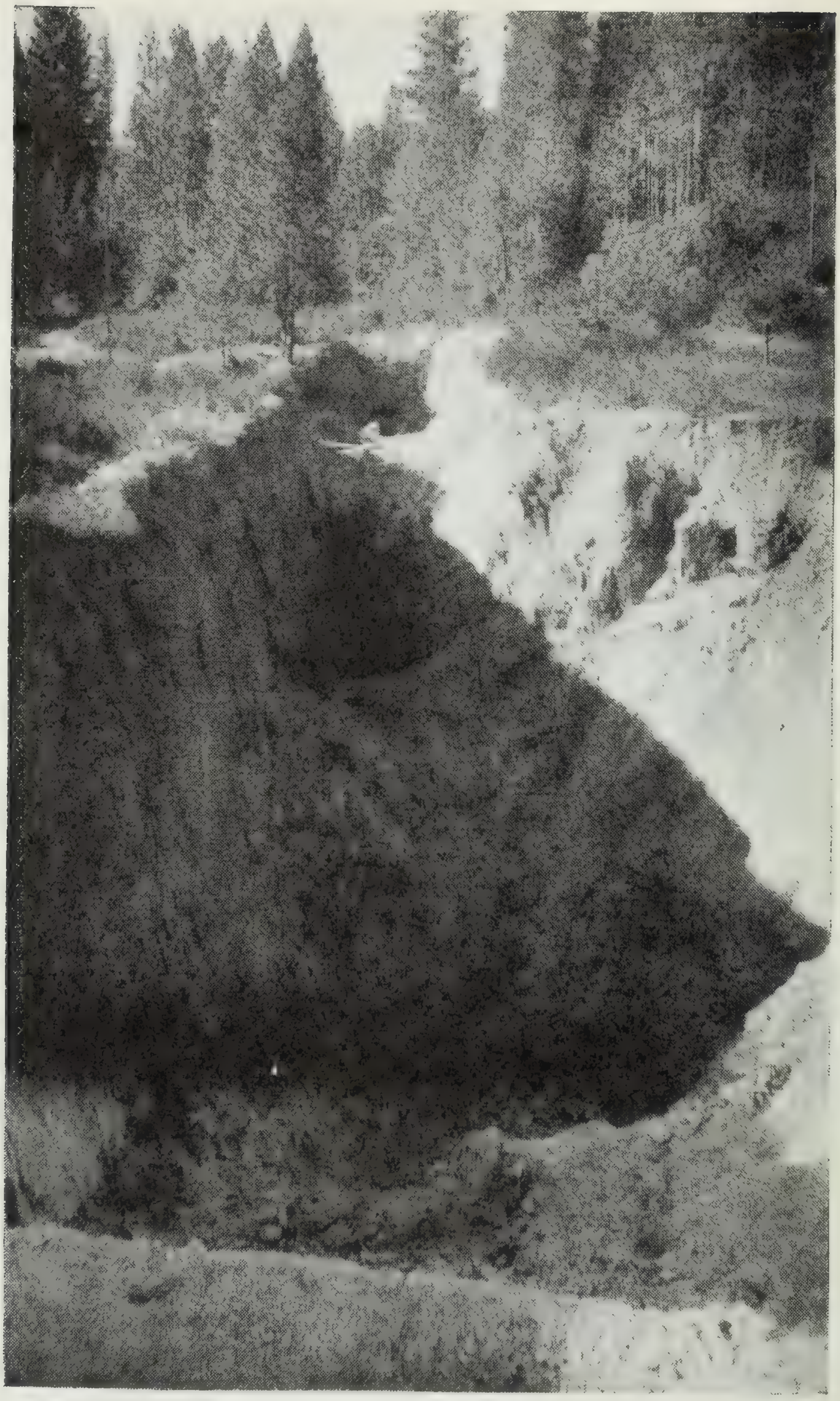
Ball Brothers Drift Mine. About 3½ miles south and east of Omo P. O. An adit was run 1250 ft. to reach gravel, on which a drift was run south 600 ft. Work was then turned eastward to follow what is thought to be the main channel. This consists of tight gravel about 80 ft. wide in which some pay is reported. Late in 1935, Rio Escondido Mines, Incorporated, Seattle, Washington, was incorporated in Delaware and announced plans to work this deposit.

Barnes-Eureka Mine (formerly *Barnes and Greenstone*) contains two patented claims, 3½ miles north of east of Shingle Springs. Here a narrow body of serpentine extends for several miles north and south as a dike in greenstone, and these claims are among those which have produced small amounts of gold, so far as recorded statistics are concerned. Arsenopyrite and gold tellurides are reported to occur. The last known production, amounting to a few tons of ore that yielded about $10 a ton, was in 1912. Numerous shallow openings were made along the vicinity of the contact, and two shafts were sunk, one reported 350 ft. deep with 60 ft. of drifting on the 200-ft. level and a small stope to the 100-ft. level. The other shaft, 77 ft. deep and south of the first, was being reopened April 28, 1936, by five partners, including A. Swinburne and W. R. Woock of Auburn. A small pump, gasoline engine and single-drum hoist were in use. Although little quartz shows on the surface on these two claims, there is, said to be a vein averaging 2 ft. wide in some of the workings, but these were inaccessible at time of visit.

Beebe Mine. Beebe Gold Mining Company, Crocker Bldg., San Francisco, has continued operation of this mine since the publication of Bulletin 108, in which it was described. The holdings include the Beebe, Eureka, Woodside and Eureka mill-site.

A new shaft on the vein was raised from the 500-ft. level to the surface about 190 ft. from the old one. A winze has been sunk 200 ft. from the 500-ft. level at a point 520 ft. northeast of the main shaft and in July, 1938, ore was being stoped from the 600-ft. level in the Eureka ground. A length of from 500 ft. to 600 ft. along the strike was worked from the surface to a depth of 250 ft. On the 370-ft. level, a length of about 700 ft. was drifted in ore, of which 65% was mined, the balance being left in pillars. The width stoped varied from 5 ft. to 50 ft. and averaged from 12 ft. to 15 ft. The orebody is a silicified and mineralized zone dipping about 80°E. in amphibolite schist. Narrow basic dikes occur in the fissure but there is only a 'commercial' hanging wall. Ore is mined by shrinkage stoping.

The Hadsell mills formerly used have been replaced by two 7 ft. by 36 in. Hardinge conical ball mills. Otherwise the flow sheet remains about the same as shown in Bulletin 108. The overflow from the classifiers below the ball mills passes to 24 Kraut flotation cells. The concentrate from these is thickened to 50% solids, ground in a 5 ft.



Open cut, Beebe Mine, Georgetown.

by 8 ft. Marcy mill and treated with cyanide in two 30 ft. by 8 ft. Devereaux agitators. After passing through 3 thickeners the pregnant solution is filtered and gold is precipitated by zinc dust. About 6 lb. lime per ton of concentrate is used for conditioning and cresylic acid and Zanthate Z5 are used in flotation.

The daily tonnage handled has lately been reduced from 250 to 100 tons as a result of selective mining at the Beebe and the closing of the Alpine mine in June, 1938.

Bella Vista Gravel Mine. Near the Gambling Mine on south. George Busse and John Heckenleitner, owners. Edgar F. Maylone

and Al Larsen were mining and washing a few cubic yards daily in July, 1936.

The adit workings have revealed two narrow gravel deposits, one of which is probably a bench of the other, and only 14 ft. vertically above it. The gravel lies on granodiorite bedrock and is capped by rhyolite. The upper run of gravel was found in a raise 17 ft. high from the adit at a point about 325 ft. from the portal. Gravel was mined here for a length of 200 ft. and a width of 30 to 35 ft. About 400 ft. from the adit portal, and 3 ft. above it, a drift was run on the west side of adit for a reported length of 200 ft. but this drift was caved and unsafe. Good gravel is reported in the face of it. The gravel trends south of west.

Small lots of gravel are trammed to a bin and washed in a concrete mixer carrying 200 to 300 lb. of iron balls, to clean the boulders which are then discharged through a trommel, and the fine material passes into a short sluice only six inches wide fitted with screen and carpet. Two small gasoline engines furnish power. The gold content of gravel is said to be $1 to $1.50 a cubic yard.

Steel headframe at Big Canyon Mine of Mountain Copper Co.

Conveyor and mill at Big Canyon Mine of Mountain Copper Co.

Big Canyon (Oro Fino) Mine is 4½ miles south of Shingle Springs by road. It had a 20-stamp mill before 1888 but the complete record of output is not available. The most productive of the early operations were carried on by Hayward, Hobart and Lane between 1893 and 1901. They produced $720,000 from 180,000 tons of ore. The ore shoot, which had a maximum length of 450 ft., was mined for a length of 400 ft. and an actual thickness of 60 ft. on the old 150-ft. level, but the apparent width is about 100 ft. because of the flat dip. Old reports indicate 20% of the gold was saved by amalgamation by former operators, but this is not true of recent work. The balance was saved by chlorination of concentrate. Since 1901 the mine has been sampled several times, but was idle until 1934 when Mountain Copper Company took it over for operation after extensive sampling. The old shaft was 800 ft. long on the incline or about 500 ft. deep vertically. Ore had been stoped out to the 500-ft. level.

The present company sank a new 3-compartment inclined shaft 620 ft. on 45° incline, 400 ft. north of the old shaft. No. 1 level, 315 ft. deep on the incline, has been opened 1400 ft. No. 2 level, 525 ft. deep on 45° incline, has been run a total of 1970 ft. On the north the ore split up. On the south, another lens of low grade, believed to be a replacement of quartzite, was found. The vein strikes S. 25° W., turning to the west on the south end. The average dip is not over 40° and generally about 35° east.

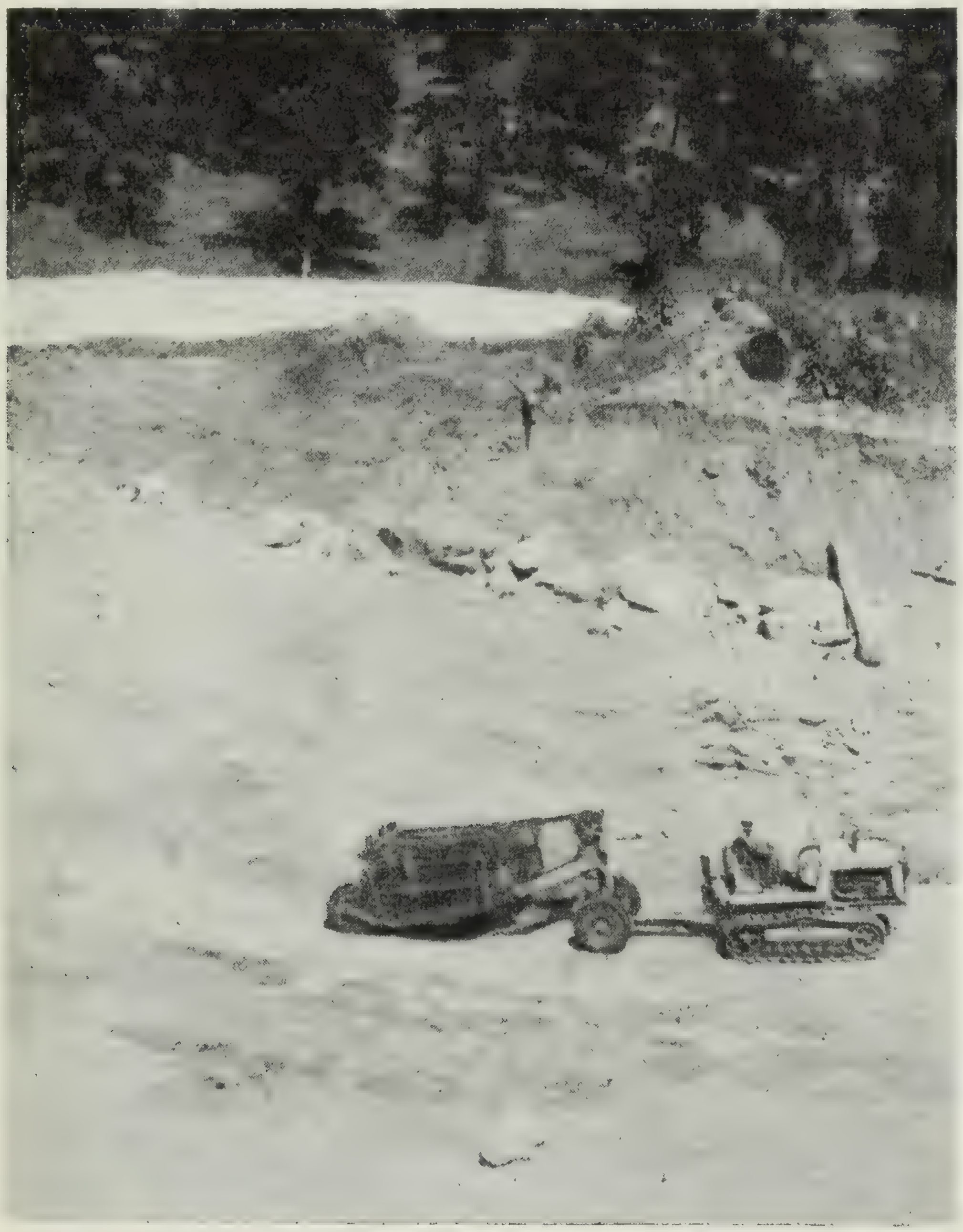
The ore, often described as altered meta-andesite breccia, has a dike of serpentine between it and the Calaveras (Carboniferous) hanging-wall rocks. On the west it merges into amphibolite schist. The work of the present company has brought out many interesting points concerning the ore and its parent rock. The good ore has been found to consist of about equal parts of albite, ankerite and quartz, of which albite appears to be necessary, or at least highly favorable, for gold deposition. Rock of very similar appearance superficially, and provisionally termed quartzite, but lacking the albite, does not make ore. J. M. Basham, superintendent, reports three periods of

sulphide mineralization. The first is of arsenopyrite, the second of barren pyrite and the third of auriferous pyrite. Only 4% of the gold is recovered by amalgamation. Microscopic examinations have shown that the balance of gold is in quartz which in turn is locked up inside of pyrite crystals not coarser than 60 mesh. With 54% of the gold in pulp of —325 mesh, and in view of the fact that grinding below —60 mesh was considered uneconomical, Basham advised a flotation plant instead of cyanidation, in spite of favorable cyanide tests on oxidized ore. Flotation has proven very successful.

Mention of quartzite, and the occurrence of what appear to be water-worn pebbles, suggest that the igneous rock picked up and engulfed some of the sandstone and shore-line conglomerate of the adjacent Calaveras beds.

The orebody has been found to wedge out in depth. Because of the serpentine, former operators left a layer of ore on the hanging wall. The present company has found the walls stand well but has been filling. The ore is so hard that 60% gelatin is used for blasting, which is all done electrically.

On February 26, 1937, water from Big Canyon Creek, which flowed directly above the mine, began to enter the workings. The few men in the mine at the time were safely removed and steps were taken

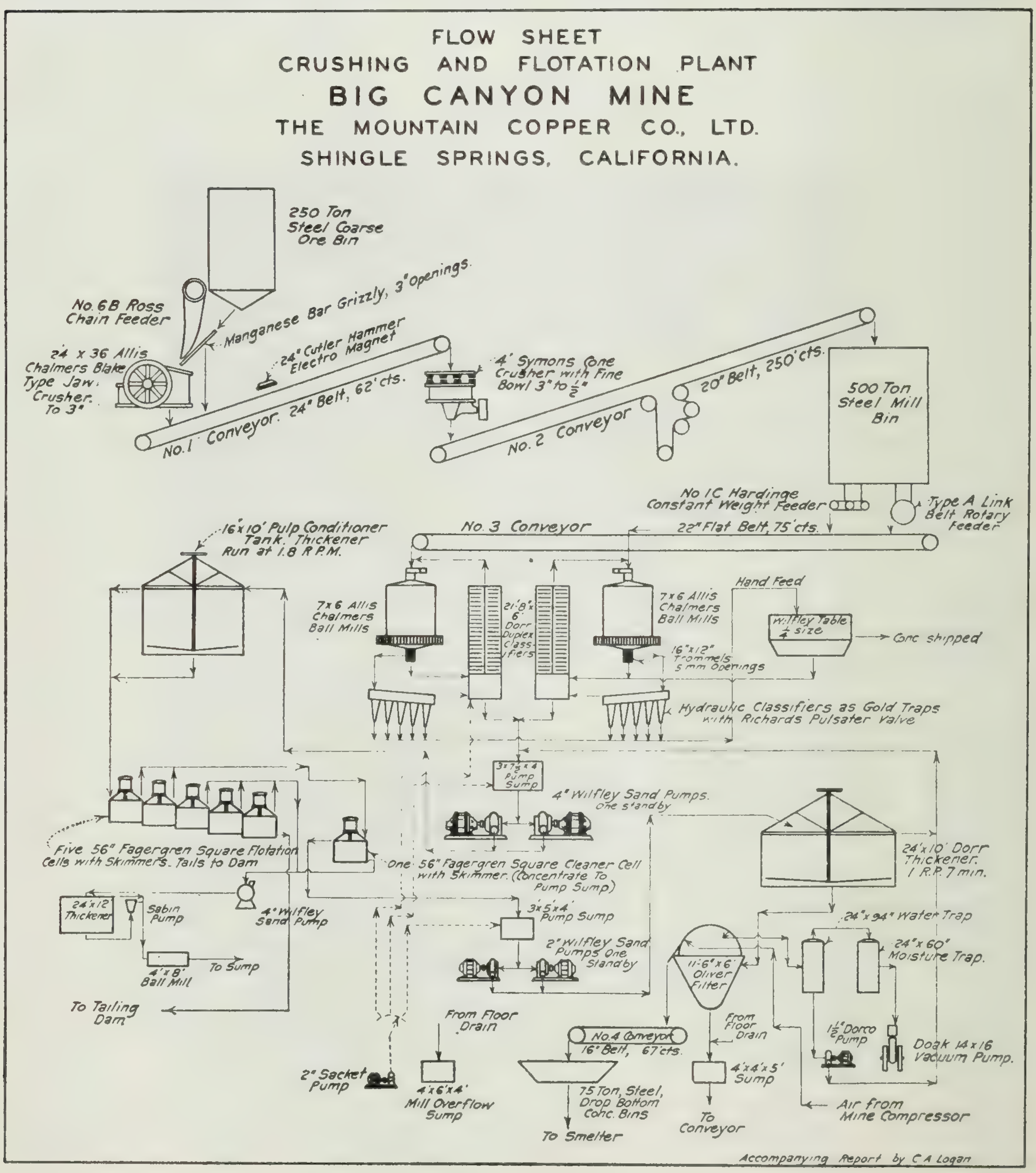


Stripping vein at Big Canyon Mine to facilitate mining ore in upper levels.

to facilitate the dewatering later. Within 52 hours 30,000 gallons of water had poured into the mine, and then a pond of water several hundred feet long formed on the surface. Work was started first on a 78-inch corrugated galvanized iron pipe-line on the east side of the creek to divert the water and carry it past the mine workings.

Later a contract was let to strip rock to below the old 100-ft. level to make available the remnants of ore in the upper part of the mine. This work was finished by July 1, 1937, and mine operations were resumed.

The mining and milling plant are substantial and up-to-date. Ore is hoisted in 4-ton skips operated by a Nordberg double-drum hoist with 165-h.p. electric motor. In the third compartment a 1-ton skip is used for tools and material. Compressed air is supplied by 2 compressors, one of 1300 cu. ft. f. a. capacity run by a 200-h.p. motor and one of 1500 cu. ft. capacity with a 290-h.p. motor. Hoists and compressors are housed in one building. The 75-ft. steel head-



frame has a built-in receiving bin from which oversize over a grizzley goes to an Allis-Chalmers 24 in. by 36 in. jaw crusher which crushes it to 3-inch size and it is then reduced to $\frac{5}{8}$-inch to $\frac{3}{8}$-inch by a Symons cone crusher. The crushers and conveyors are interlocked electrically so that no unit can run when the one next in line has been stopped.

Fine grinding is done by a 2 Allis-Chalmers 7 ft. by 6 ft. ball mills in closed circuit with 2 Dorr double rake classifiers. The classifier overflow (minus 60 mesh) is pumped from 2 steel sumps to a conditioning tank under the mill roof, where it may be held 2 hours before passing to the 5 Fagergren flotation cells and 1 cleaner cell. After the plant had been operating some time, a higher grade ore was found, and the insoluble content of the concentrate increased with this. A 4-ft. by 6-ft. ball mill was put in to regrind the middling product and reduce the insolubles. Concentrate is run through a Dorr thickener and an Oliver filter and then hauled by trucks to Stockton where it is shipped by steamer to Tacoma smelter. Ore yielding $5 a ton or more is considered satisfactory. The ratio of concentration is $13\frac{1}{2}$ to 1. A crew of 150 men produced about 300 tons daily when in full operation.

The surface plant at this mine was described in detail by John B. Huttl, in Engineering and Mining Journal for May, 1935.

Black Gold Mine. This small drift mine in the NW$\frac{1}{4}$ sec. 29, T. 10 N., R. 12 E., adjoins the Hinds Mine in Pleasant Valley district. It included the western part of the original Hinds location, and a lease on other land, a total of 153 acres.

The same bench deposit of fine, loose quartz gravel found first by Hinds was worked through a 60-ft. shaft sunk $19\frac{1}{2}$ ft. from the east property line. Drifts were run west 100 ft., north 280 ft., and east 127 ft., and a few thousand dollars in gold was produced. In a report to stockholders in July, 1930, an average recovery of $3.23 a ton was claimed from gravel breasted up to that time. For milling gravel, two 10-stamp Straub mills with plates and a concentrator were used. Gravel through $1\frac{1}{4}$-inch screen was crushed to 15 mesh. The gravel was sticky but not cemented.

In January, 1931, Black Gold Mining Company quit. Later, Flavel Atkinson had a short lease and is reported to have mined some gravel 50 ft. wide which yielded up to $5 a cu. yd. In 1936, *Ventura Mine Associates, Incorporated,* had a lease on the property, which they plan to prospect through an adit being run southward from the Ventura Placer Mine in sec. 20, on the north side of the lava-covered ridge.

Black Oak Mine is in the NW$\frac{1}{4}$ of SW$\frac{1}{4}$ of SE$\frac{1}{4}$, sec. 27, T. 12 N., R. 10 E., near Garden Valley school. Since the last report (in Bulletin 108) this mine has been in steady operation and has been one of the more important producers of the county. It lies near the narrow southern end of a long body of amphibolite schist which for several miles separates the Mariposa slates into two branches. Although nearly 2 miles wide at the maximum, it has a width of only a few hundred feet in the vicinity of the Black Oak. The mine is part of a placer patent.

It has been opened by a vertical shaft 400 ft. deep (Oct., 1937) and has been stoped from the 400-ft. to 50-ft. level, with levels at 120, 150, 220, 300 and 400 ft. deep. A series of small faults with a horizontal throw of from 4 ft. to 6 ft. was encountered. The widest portion of the vein was between the 220-ft. and 300-ft. levels where specimen ore was found scattered through a width of 22 ft. Nearly all of the work has been done south of the shaft. Going south on the vein, it feathers out. On the 400-ft. level south, the footwall is sheared greenstone (amphibolite schist) in which chlorite schist has been developed. The hanging wall is claimed to be blacker and is locally called 'slate'; an inspection of hand specimens in full daylight shows they appear identical. Here the vein consists of a quartz and calcite stringer lead, with calcite seams making out into the hanging wall. The gold is claimed to be practically all in the calcite. To the north the vein is reported to be solid quartz and calcite from 10 ft. to 12 ft. wide. In the ore zone, the average thickness mined is said to be 8 ft. and the stope length 100 ft.

Although the operator is now inclined to minimize the effect of the small faults (the uppermost of which was mentioned in Bulletin 108 as having apparently been instrumental in localizing the accumulation of gold near the 50-ft. level) these were probably a favorable factor. At least one was encountered in stoping from each level.

The total recorded production of the property up to October 7, 1937, has been $417,303 in gold. Losses through theft have been rather high. Although the total stolen can only be guessed, $16,000 in gold stolen from the mine has recently been recovered in a round-up of 'high-graders.' The term "average grade of ore" is not applicable to such a property where so much of the pay is in 'high grade.' During the latter operations a milling plant with a capacity of 35 tons a day has been operated. It contains large and small crushers, Williamson ball mill, a Dorr classifier, hydraulic trap and 3 Fagergren flotation cells. It was planned to put a Denver jig in place of the hydraulic trap.

For some time, *Dayton Cons. Mines,* a Nevada corporation, has been prospecting the land on three sides of the Black Oak mine in the effort to pick up a part of the rich ore zone on the dip or strike. The properties involved in this development project were the *Davey,* adjoining the Black Oak on the north, the *Clark* land on the east and the *Davenport* claim adjoining the Black Oak southeast on the strike. Of immediate interest in connection with the Black Oak was the work on the Davey land where a shaft was sunk. This work was started in 1934 by M. J. Kelly and Geo. P. Morgan, who took out a little ore which was crushed at the Hart mill. In 1936 the Dayton Consolidated took the property and sank the shaft to the 500-ft. level. Work was carried on until January, 1938, when a 'strike' was reported on the 500-ft. level on the dip below the Black Oak workings and east of the side-line. A few days later it was announced that the Dayton Consolidated was turning over its leases and options on these three holdings to the owners of the Black Oak mine.

Blue Gouge and Berg Mines. The Blue Gouge is on Camp Creek about two miles northwest of Baltic Peak Lookout and may be reached by roundabout roads from Pleasant Valley. In 1895-1896, when it

was being extensively prospected by Mackay, Flood and associates, it was described in Report XIII of the State Mineralogist. It was abandoned shortly afterward and little has been done upon the claims since. Seven unpatented claims, covering most of these old prospects were leased in 1936 to D. A. Raybould with an option to purchase.

The deposit, revealed by erosion in the canyon of Camp Creek, is a zone 400 ft. wide exposed for a reported length of 3500 ft. along the canyon side, and rising several hundred feet above the creek. Several veins of quartz traverse this zone of slate and schist which also carries seams and small lenses of quartz. The footwall is Calaveras formation (Carboniferous) and the hanging wall, eroded and oxidized, is diorite or granodiorite. The strike of the zone is N. 30° W. and dip is 78° NE.

Seven crosscuts at different levels have been run across the central part of deposit from the canyon slope. These vary in length from 121 ft. to 316 ft, and total over 2000 ft., the deepest giving 235 ft of backs. These are claimed to indicate two blocks of low-grade material 1000 ft. and 1500 ft. long containing several million tons. Assay values are reported from $1.60 to $1.98 a ton (old gold price) for several hundred samples.

The Berg ground lying north of the Blue Gouge, and with an apex 100 ft. higher is claimed to contain a block of similar material about 1000 ft. long. Very low mining costs are possible because of the topography. The oxidized zone is underlain by fresh rock carrying 2½% of auriferous iron sulphide which is claimed to assay $85 a ton (old gold price).

Camp Creek carries sufficient water for milling a large daily tonnage, but it is not known how much of this water belongs to the claims. There is plenty of good timber nearby.

Bollhalter quartz prospect. One mile north of Weber Creek east of Lotus road, on an agricultural patent. Besides this 147-acre patent, Mrs. Mary Bollhalter has 70 acres in placer locations on a small stream nearby.

A large outcrop has been uncovered for a length of 75 feet on top of a hill, where it strikes east. Reported assays of $1.40 and $3.80 a ton are claimed by the owner from random pieces of quartz. Near the north property-line a stringer lead of quartz in manganese-stained greenish amphibolite schist is said to have yielded pockets from a pit 10 by 10 by 20 ft. The country-rock forms a narrow peninsula extending southward for one-half mile into serpentine. No late work has been done here.

Bret Harte Mine. Frank Dean, owner. In NW¼ sec. 6, T. 11 N., R. 12 E. Three claims, on the north slope of Slate Mountain ¾ mile by trail from the road.

An adit 240 ft. long has been run on the Bret Harte claim, and one 140 ft. long on the Safeguard No. 1 claim. During and prior to 1934, a few hundred tons of ore was milled in a Tetrault mill. This came from the surface, and was not in place. The 240-ft. adit gives about 150 ft. of backs on a vein which has been followed 60 ft. and is from 2 inches to 14 inches thick. The other adit shows from 18 inches to 36 inches of quartz which has been followed 50 ft. Idle in 1936.

Briarcliffe Mines, Ltd. (*Baldwin or Nashville Mine*). The adjacent *Maginess* and *Last Chance* claims are also held under option by the company. These claims are two miles east of Nashville and are reached by three miles of road from the Mother Lode highway.

Shallow shafts and adits were run years ago on these claims but apparently the total output was small. About 1914, O. N. Hirst reopened the Baldwin shaft, then 225 ft. deep, and did some work on the 100-ft. and 170-ft. levels. The vein had been previously stoped from the 100-ft. level to the surface. On the Last Chance a 10-stamp mill was operated a short time in 1909 on low-grade rock by *Monarch Consolidated Mines Company.* On the Inez Central (Maginess) there is an old shaft 250 ft. deep from which some ore was produced and hauled to Nashville for milling.

The present company began work in January, 1932 and began milling with 10 stamps a few months later. This mill was run part of the time until March, 1935 when a 100-ton flotation plant was put in commission. This was in steady operation from October, 1935 until July 3, 1936, when the mine and mill were closed down and have been idle since. The late manager, Ray Morrow, stated that labor troubles were chiefly responsible for the suspension, which is hoped to be only temporary. Over 30,000 tons of ore was milled.

The Baldwin claim is 3000 ft. long by 300 ft. wide, and the Last Chance (or Nome) group adjoining it on the east cover the same length. On the Baldwin, where work has been concentrated, the hanging wall is amphibolite schist and footwall slate. This land lies a mile east of the recognized course of the Mother Lode but the character and value of ores found are similar in both, though the best pay at the Baldwin is said to be in the quartz and schist on the hanging wall side. The strike of vein is N. 10° E. and dip 72° NE.

The company ran the main tunnel 895 ft. north to the old Baldwin shaft and 100 ft. beyond it, reaching a depth of 290 ft. below the apex. The shaft was connected with the tunnel. At a point 500 ft. from the tunnel portal, a winze was sunk on an angle of 72° to a depth of 500 ft. (with 25-ft. sump). Levels were turned from winze at depths of 125, 275 and 500 ft. Ore was mined from all three of these levels, with stopes reported of a maximum width of 60 ft. to 70 ft. No. 7 level was drifted about 100 ft. each way on vein and is claimed to be all in ore, in what is called the south or Morrow shoot. Besides this there is the old Baldwin shoot at the old shaft, from which this company mined over 10,000 tons. The average reported yield was $3 to $4 a ton in 1934 to 1936 though some ore stoped on the hanging wall in the deeper levels is claimed to have been much better.

After passing through a Symons cone crusher and being ground to —200-mesh in a 4-ft. by 5-ft. Hendy ball mill, ore was put through a Morse Brothers unit flotation cell and 16 M. S. cells. Water for milling was pumped from Middle Fork of Cosumnes River through 4300 ft. of pipe-line with 475 ft. lift. Electric power is used. When mining and milling 100 tons daily, 48 men were employed.

The company is stated to have been financed entirely with Canadian capital. The main office is in the Supertest Building, London, Ontario. J. G. Thompson, president.

Buckeye Hill Placer Mine (*Flora Mine*), nine miles northeast of Georgetown was worked extensively in the 1890's by J. J. Flora. It contains an ancient channel deposit 1000 ft. wide carrying layers of gravel alternating with "cement," the total thickness being 127 ft. where it was hydraulicked on the west side. A good deal of drift mining was also carried on through adits, breasts being 100 ft. wide in the bottom gravel, where coarse gold was found. Timber was pulled out after working this ground so that the old 600-ft. adit caved. Later work was done on a bench above.. A few years ago, Oscar Jacobson and associates, the present owners, did some work on the north rim through an adit 125 ft. long, dropping gravel to a 400-ft. bedrock adit. Water for washing is scarce and has to be lifted 500 ft. by pumping and then piped 1300 ft. to a Beers mill. The gravel is loose and is reported to yield $1 (old price) gold per 1500-lb. carload. The gold is coated black.

Bucks Bar Placer. On North Fork of Cosumnes River two miles north of Youngs P. O. The Hutton property lying on both banks of the river just upstream from the highway bridge contains a gravel deposit from 8 ft. to 16 ft. deep and claimed to carry about 800,000 cu. yds. on decomposed granitic bedrock. Bradford, Cross and Prior of Sacramento are reported to have been interested in a drag-line outfit which operated here a short time without success. Lately (July, 1936) the land was taken on lease by Los Angeles interests who planned to install another placer mining plant.

Buena Vista Mine. This is an old claim six miles south of El Dorado by road passing the Union and Martinez mines. According to Storms[1]

"The veins are found in Calaveras formation—mica-schist at this place. A small vein running parallel with the strike and dip of the schists has been followed for some distance in search of pockets with satisfactory results. A former operator who prospected this mine, in some way was misled as to the value contained in a schistose zone impregnated with iron sulphides, and expended nearly $50,000 on the property doing considerable development work, erecting numerous buildings and a mill. The rock proved almost valueless, and the mine was closed. The present owners, however, are doing well."

The mine's name does not appear as a producer in records of that period. It lay idle many years until 1936 when John J. Schuster obtained an option and later formed Buena Vista Mining Company to reopen and prospect the workings which include a shaft reported to be 208 ft. deep, an adit, and drifts 400 ft. or more in length. Work had been suspended early in May, 1937. It was said the company did not completely unwater the workings.

California Consolidated Group comprises three claims south of Mt. Pleasant Mine and covering 4500 ft. along the strike of veins supposed to be extensions of some of those in the latter mine.

An adit 468 ft. long has been run and it is estimated by the owner that 225 ft. more work will be required to strike what he believes is the Mt. Pleasant vein. This adit would give 300 ft. of backs. Some ore mined from shallow workings years ago on the Tapioca vein, was hauled to the Morey mill and is claimed to have yielded $11.30 a ton. Other samples varied from $6 to $11 a ton. The claims lay idle

[1] Storms, W. H., Calif. State Min. Bur. Bull. 18, p. 91, 1900.

a long time, until work was resumed recently by Marie H. Johnson and others.

Crystal Mine. In sec. 18, T. 9 N., R. 10 E., 3 miles south of Shingle Springs. It is being prospected by Oakleigh Thorne with Ben Lockwood, superintendent. In June, 1937, 25 men were employed. This is an old mine, once equipped with a 10-stamp-mill but idle many years. There is one claim 1220 ft. long.

The present work is being done through an adit level run 1028 ft. north through the hill, with the north section in broken and muddy ground. At 328 ft. from the portal, a winze has been sunk 480 ft. on 45° angle, following the dip of ore. Levels 2, 3 and 4 have been turned at depths of 200, 326 and 456 ft. respectively on the incline. Most of the work below the adit level has been done on No. 3 where a drift of 240 ft. north and 40 ft. south is claimed to be all in ore, reported as varying from 8 ft. to 24 ft. in width. The writer noted a width of 12 ft. at one place on this level where the vein strikes north and dips 42° E. In No. 2 raise crosscut, and in other parts of the mine, the vein material is frozen tight to both walls, which appear to be identical. A sample of the wall rock has been classified by Frank Sanborn as amphibolite-chlorite schist. It is dark green, fine grained and appears black under ground. On No. 4 level, drifting had extended 30 ft. south and 50 ft. north at time of visit.

From inspection underground, it appears that the vein material was deposited in the irregular cracks and occasional cavities in the schist resulting from the smashing and crushing which occurred when the gabbrodiorite entered the country to the west. In places in the mine small open cavities were formed, and in these growths of quartz crystals are found. The whole effect has been the formation of a very irregular vein. An examination of a thin section of typical vein mate-

Surface plant at Crystal Mine, south of Shingle Springs. Steel cyanide tanks in right foreground.

rial from the third level was made by Frank Sanborn and Charles V. Averill. This was stated by the superintendent to be good ore. It was found to consist of quartz, feldspar, calcite and pyrite. Some albite twinning was noted, but the feldspar, although apparently more plentiful than the quartz, was mostly in crystals too small to permit telling whether it was albite or adularia.

Hoisting is done with a 20 h.p. Box Iron Works Denver electric hoist. Near the portal of adit there is a 600-cu. ft. Worthington air compressor run by a 100-h.p. motor; a drill sharpener and smaller tools all housed in new buildings. About 5000 gallons of water is raised daily with a duplex piston pump on No. 3 level and pneumatic sponges in the sump.

Assays are claimed to indicate ore ranging up to $11 a ton in gold.

In July, 1938 a reduction plant with a capacity of 100 tons to 125 tons a day was completed and put in operation. Ball milling and cyanidation are employed. Dams have been built for conserving water and restraining tailing in French Creek. It is expected about 45 men will be employed when in full operation.

Expansion Mine. In SE¼ of SW¼ sec. 17, T. 10 N., R. 10 E., about seven miles by road north of Shingle Springs. This prospect is on one of the deposits of disseminated pyrite in silicified amphibolite schist so common in the western foothills. Serpentine lies on the footwall. The lower adit, 150 ft. long, is a crosscut which for 40 ft. crosses a mineralized belt which gives gold assays, all the gold being reported in the sulphide. This work, done years ago, just entered fresh rock showing unoxidized sulphide with some bluish quartz.

Although claimed to have been a producer between 1900 and 1904, no record of output is available.

Ferriera Claim. Contains 20 acres in sec. 29, T. 10 N., R. 12 E., on the east end of Newtown ridge. In 1930 A. Neistrum sank a shaft 135½ ft. deep to slate bedrock in search of gravel. No pay was found, although 13 g.p.m. of water had to be pumped.

Fort Yuma claim is lot 49 in Secs. 29 and 32, T. 9 N., R. 10 E., 1¾ miles by road southeast of Big Canyon Mine. Under lease to George Phillips, Sacramento and George Wilson, in August, 1938.

Between 1890 and 1902 this property was worked by Hale and Baughman but there is no record of any ore having been milled, although a stamp-mill was taken to the claim. There is an old shaft reported to be 175 ft. deep from which some drifting was done, and to the south is a second shaft 40 ft. deep. The vein filling on the surface varies from 2 ft. to 4 ft. wide, including from 2 ft. to 2½ ft. of solid quartz. The strike is nearly north and dip is steeply east. Both walls are Calaveras slate.

With 8 men employed in August, the lessees have cleared the shaft to the 100-ft. level and have opened the drift on that level 132 ft. south and 119 ft. north. A Lane mill and 4 Fagergren flotation cells have been installed and a test run of 100 tons of ore gave satisfactory returns. An electric power line a mile and a half long has been built. Water is taken from Big Canyon Creek through 1500 ft. of pipe and 2000 ft. of ditch.

Fossati Drift Mine (*Tunnel claim*). It is about $1\frac{1}{2}$ miles south of Camino, on Goose Nest Ravine east of Sailor Jack Mine. Old workings, besides surface placer mining, included the adit now called Green Tunnel running west from the ravine, and a shaft through which some gravel was taken out. About 1930, Charles Croft drove another adit 500 ft, north of and 50 ft. above the Green tunnel. From this a raise 200 ft. in struck gravel 14 ft. above the adit, and some production was made from it. The main adit was advanced 50 ft. further where it passed through a channel rim which was followed down for 50 ft. on an incline. Over 400 ft. of drifting was done from the foot of this incline, when the lease was transferred to J. S. Green. The latter did considerable prospecting through the Green tunnel which was advanced northwest toward the channel that had been worked by Croft. At about 620 ft. from the portal in the right branch of this tunnel No. 3 raise was put up, striking good gravel 26 ft. above the tunnel. Some small breasts were opened in this, but in June, 1934, the property was turned back to the owner. In September, 1934, R. W. Waterman began work for another group of lessees, *El Dorado Channel Mines, Inc.*, and did some additional work which showed the channel varied greatly in width and gold content. Funds were exhausted before much new ground was opened, and work was stopped in September, 1935.

The deeper channel in the different workings ranges from 25 to 200 ft. wide and the gold content varies from 50 cents to several dollars a yard, mostly in coarse sizes, up to an ounce each. The gravel is tight and lumpy enough to require a trommel.

The gravel found in No. 1 raise and other shallow workings is of a different run, with gold the size of bran.

In May, 1936, this claim was reported under lease to Charles Woods and sons.

Frog Pond Mine. It is $\frac{1}{2}$ mile northwest of Garden Valley, in decomposed igneous rocks enclosed in Mariposa slate. Work has not reached sufficient depth to expose fresh rock, but it is probably amphibolite schist found commonly in the region.

The surface of the claim was worked extensively for the gold released by weathering, and later Samuel W. Collins sank a shaft 60 ft, from which a drift and incline has been run south between 80 ft. and 100 ft. Coarse gold was found both in quartz and in lumps of arsenopyrite, in a series of seams. No work is going on at present.

There is a 2-stamp mill which was used at intervals between 1914 and 1927 to crush small tonages of ore and has been used also at times as a custom mill for ore from other nearby mines. Water for milling must be purchased from a public utility company.

Gambling Mine. Joe Lopez, Plymouth and Tony Levaggi, owners. It covers 2800 ft. in length along the strike of vein, and 40 acres of additional mineral rights, in sec. 5, T. 8 N., R. 12 E., south of Aukum-Fairplay road.

The vein strikes east and dips 80° south with an average width reported to be 18 inches, but 30 inches wide in the bottom according to Joe Lopez. It has been idle since late in 1934 and the workings could not be visited. Both walls are granodiorite with a narrow gouge on each.

The shaft is 500 ft. deep on an incline of 80°. The upper 350 ft. was sunk between 1915 and 1918, when the 350-ft. level was also run 700 ft. east and 240 ft. west. The later work in 1933 and 1934 included 150 ft. of shaft sinking, with drifts 150 ft. each way on the vein on 225-ft. level and 180 ft. each way on 450-ft. level. There is also an adit called 90-ft. level on which considerable drifting was done. The only stoping reported was a little on the 350-ft. level, besides which part of the ore from the drifts was milled.

The plant includes a good galvanized-iron mill-building, with 10 stamps, a jaw crusher, four 12-ft. Frue vanners, plates, clean-up barrel and 4-cylinder tractor engine; a single-drum steam hoist, Bury compressor, and Pomona pump. The shop contains a drill sharpener and oil-fired forge. Three cords of wood was required daily at a cost of $10 to furnish steam, and power was scarcely adequate for all requirements.

Gilt Edge (Revenge) and Consolidated claims are in the NE¼ sec. 10, T. 12 N., R. 10 E., 1½ miles southeast of Greenwood. It is one of the mines on the Greenwood seam belt, formerly worked by hydraulicking. Only a little pocket-hunting on the stringers exposed in the old pit has been done in late years. Some specimen ore was exposed by this work but production has been nominal and has not been separately recorded. Properties of this kind are difficult to sample except on a large scale, because of the capricious distribution of the gold throughout a large volume of rock. The geology of the 'seam mines' has been discussed elsewhere.

Grand Victory Mine is in secs. 33 and 34, T. 10 N., R. 11 E., 4 miles by road southeast of Diamond Springs. It is an old mine, which was found in 1857, but little was done until 1879 when a 5-stamp mill was built. This was increased to 50 stamps in the latter part of 1880, and in 1883 the mine was reported to have produced a total of $150,000 in free gold from open cuts at an operating cost of 65 cents a ton. There was little sulphide in this oxidized ore, but soon after the work reached unaltered sulphides. Concentrators were installed and a reverberatory furnace was erected, but little success appears to have been had for several years. The ore was said to carry antimony and arsenic and recovery was said to be poor at that time, leading to the suspension of work before 1890. About 1894, a cyanide plant was installed and was operated to treat oxidized ore until late in 1901. The total production during this period was over $85,000. The record of production between 1883 and 1890 is not available. In 1885 the mill was reported to be crushing 225 tons a day with an average yield of $2 a ton.

After being closed in 1901, the mine lay idle until July 1, 1933, when work was resumed and prospecting and sampling was carried on for nearly two years. Although the former operators had sunk a winze giving a depth of 385 ft. below the outcrop, practically no stoping had been done below the 100-ft. level except a little at 200 ft. Most of the ore milled came from three open cuts, which are from 100 to 135 ft. wide at the surface and extend for a total length of 530 ft.

The new work consisted of cleaning out the winze and running several thousand feet of crosscuts and drifts on the 200-ft. and 300-ft. levels. The winze giving access to the deeper workings had previously been sunk from the main adit 450 ft. from the portal. The workings on the 300-ft. level consist of a drift about 970 ft. long running from the shaft northeast and north, with a number of crosscuts from it. The limestone bodies, alongside of which the ore lies, strike N. 70° E. on this level. Five such bodies, from 12 ft. to 33 ft. thick, have been cut. The ore is a dense, heavy silicified member of the Calaveras series which here includes principally silicified schist, quartzite and limestone. The mine is within one-half mile of surface exposures of a granodiorite batholith. Acid dikes run about parallel to the ore bodies and diorite dikes strike N. 51° E., N. 58° E., and S. 77° E. In places the limestone is faulted with a horizontal throw of a few feet, but this faulting does not seem to be definitely associated with the dikes. On this level ore was crosscut 22 ft. wide and 270 ft. of drift was run in ore, and a raise was put up in ore. Four diamond drill holes from 150 to 250 ft. long were run. On the 200-ft. level, the longest crosscut was run N. 15° W. 372 ft., besides which about 1080 ft. of shorter ones were driven. The strike of ore on this level is N. 40° E., diagonally across the strike of schistosity of the wall rocks, which is N. 80° E. This variation from the normal northwest strike of the Calaveras rocks is no doubt due to the effect of the granodiorite invasion. About 180,-000 tons of sulphide ore is claimed to be reasonably indicated, though not blocked out.

There are four good galvanized iron buildings and some old wooden dwellings on the mine. Mine equipment includes a sinking pump of 170 g.p.m. capacity, with 25-h.p. electric motor, Sullivan compressor with 125-h.p. motor, Clyde single-drum hoist with 35-h.p. motor, and shop tools.

The workings are reported to make an average of 60 to 65 g.p.m. of water, but sudden and heavy flows are likely to occur whenever a cavern is opened in the limestone.

Greenwood Quartz Mine at Greenwood was leased in 1935 to T. W. Carpenter and sons, who erected a plant containing two 4-ft. by 8-ft. ball mills and cyanide equipment for treating the material from the seam deposit which they believed carried enough gold over a width of 200 ft. to pay for working. After a short period of operation during which a gasoline shovel was used to mine surface material, work was suspended.

Hart Mine in N½ sec. 27, T. 12 N.; R. 10 E.; on the 'seam belt' between Manhattan and Empire canyons 1 mile north of Garden Valley, was described in bulletin 108. In early days it was hydraulicked for a length of 175 ft., a width of 50 ft. and a depth of 40 ft. Later it was prospected to learn if the ore would pay for milling. Four separate stringer systems or veins were found. Drifts called Rymal and Hart adits were run on two of these, a shaft 200 ft. deep was sunk connecting with the former, and a 30-ft. shaft from the Hart adit. A raise was also put up 65 ft. to the bottom of the old hydraulic

pit. A large part of this work was done by J. A. Flink and J. B. McAuley since 1930, when they erected an 8-stamp mill. Some ore has been milled nearly every year since. The average recovery per ton over a period of 4 years (using a value of $35 an ounce for gold), was nearly $5 a ton. At the time of the last two visits, however, the mine was idle and deserted and nothing could be learned of the width and length of ore bodies.

The deposit is a stringer lead in amphibolite schist, being in the same long, narrow body which contains the Black Oak Mine. The geology of these 'seam belts' has been described in Bulletin 108. It is claimed to have a length of 600 ft. and an average width of 12 ft.

The equipment includes 8 light stamps, a concentrator, electrically operated hoist and 225-cu. ft. air compressor, with assay office, etc.

Havilah (*Nashville*) *Mine.* This adjoins the Montezuma mine on the south, and the last operations, which terminated about July, 1936, were carried on by *Montezuma Apex Mining Co.* Since then, the mine has been turned back to the owners.

When the Havilah was reopened in 1934 it was found that former operators had stoped out a short ore shoot, from 60 ft. to 75 ft. long so far as could be judged, on the north side of the shaft from the 1000-ft level to the surface. This old mine is claimed to have been the first quartz mine worked in the county. Its production had been between $350,000 and $400,000.

The last operators opened a length of 160 ft. of good ore up to 10 ft. thick on the 200-ft. level south of shaft by advancing the drift beyond the old face. It proved to be only a small ore shoot. The 1000-ft. level was cleared and 450 ft. of drift was run on the Montezuma footwall vein (the main vein of both mines). An ore shoot 80 ft. long and from 6 ft. to 15 ft. thick was found, with an average value of about $5 a ton, but it gave out before the Montezuma 700-ft. level was reached. The Montezuma 1200-ft. level was also run into the Havilah ground and a raise was put up to the 1000-ft. level 300 ft. north of Havilah shaft. On the 1500-ft. level run from the Montezuma shaft, some indications of ore were found near the Havilah line, but this extended only 20 ft. high and 40 ft. long.

Hinds (*Los Angeles*) *Mine.* In NW$\frac{1}{4}$ sec. 29, T. 10 N., R. 12 E., in Pleasant Valley district nine miles east of Diamond Springs. W. A. Hinds discovered a gold-bearing deposit of bench gravel here in 1927. After producing a few thousand dollars from a short drift at a depth of 20 to 24 ft., he turned the property over to others who called it the Los Angeles mine. They sank a shaft 48 ft. deep and ran a drift about 200 ft. northwest with a branch east 70 ft.

The gravel seen in Hinds' workings was mostly fine, loose quartz gravel but with some quartz boulders two feet thick. It lay on soft, clayey rhyolite ash and had a white sand covering. In a distance of 60 ft. drifted eastward, the bedrock dropped about three ft. This gravel was dry. The gold is all coated black and mostly coarse. A deeper and later channel, known to exist on the next property east, probably drains the section and may have eroded much of the earlier gravel.

No work has been done here for several years, the last mining having been done by lessees who made good wages.

Headframe used in prospecting a shallow gravel deposit at Hinds Mine, Pleasant Valley.

Kaeser (Boulder) Mine. This old mine, 2½ miles northwest of Deer Valley school, was active over 40 years ago, but had lain idle some time when seven claims were relocated in 1931 by F. J. Kaeser and associates. The work in the past consisted of driving adits and stoping out ore at successively lower levels on the north slope of the hill. This was followed by sinking a winze 200 ft. deep on the vein from the lowest adit. There was a lapse of 30 years between the last production reported by the old company in 1901 and the first output under the new owners in 1931. Since that year less than 1000 tons has been milled, yielding from 0.1 oz. to 0.25 oz. gold per ton.

The vein lies in gabbrodiorite near the north border of a batholith. The strike is N. 45° to N. 50° E., dip about 45° NW., and average width reported 8 ft. though where seen it showed from 1 ft. to 14 ft. of quartz, in the lower adit. This adit, the scene of the limited amount of recent work, is a crosscut south 600 ft. to the vein, which it follows as a drift 300 ft. For 60 ft. on the strike and 30 ft. above the level in a raise, the vein averages 8 ft. thick. On the strike it pinches to one foot. In the top of the raise, the fissure is completely filled with

mineralized country rock, which F. J. Kaeser claims assays high enough over a width of six feet to make good ore.

In the winze workings below this adit, which were inaccessible at time of visit, the former operators are beleived to have stoped a block of ore 100 ft. deep, and for a length of 100 ft. north of the winze, but definite details are lacking. It is claimed there is ore left in these workings, but this has not been verified by any recent examination.

The four older adits, higher on the slope, still contain low-grade quartz left after the selective mining done by former operators.

The mill contains ten 350-lb. stamps, rock breaker and small concentrator and is run by an automobile engine.

In April, 1938, the claims were under option to H. Fulmer and J. Torney, Seattle. A new adit was being run to connect with No. 4 adit (caved) and furnished ventilation for No. 5, the lowest level.

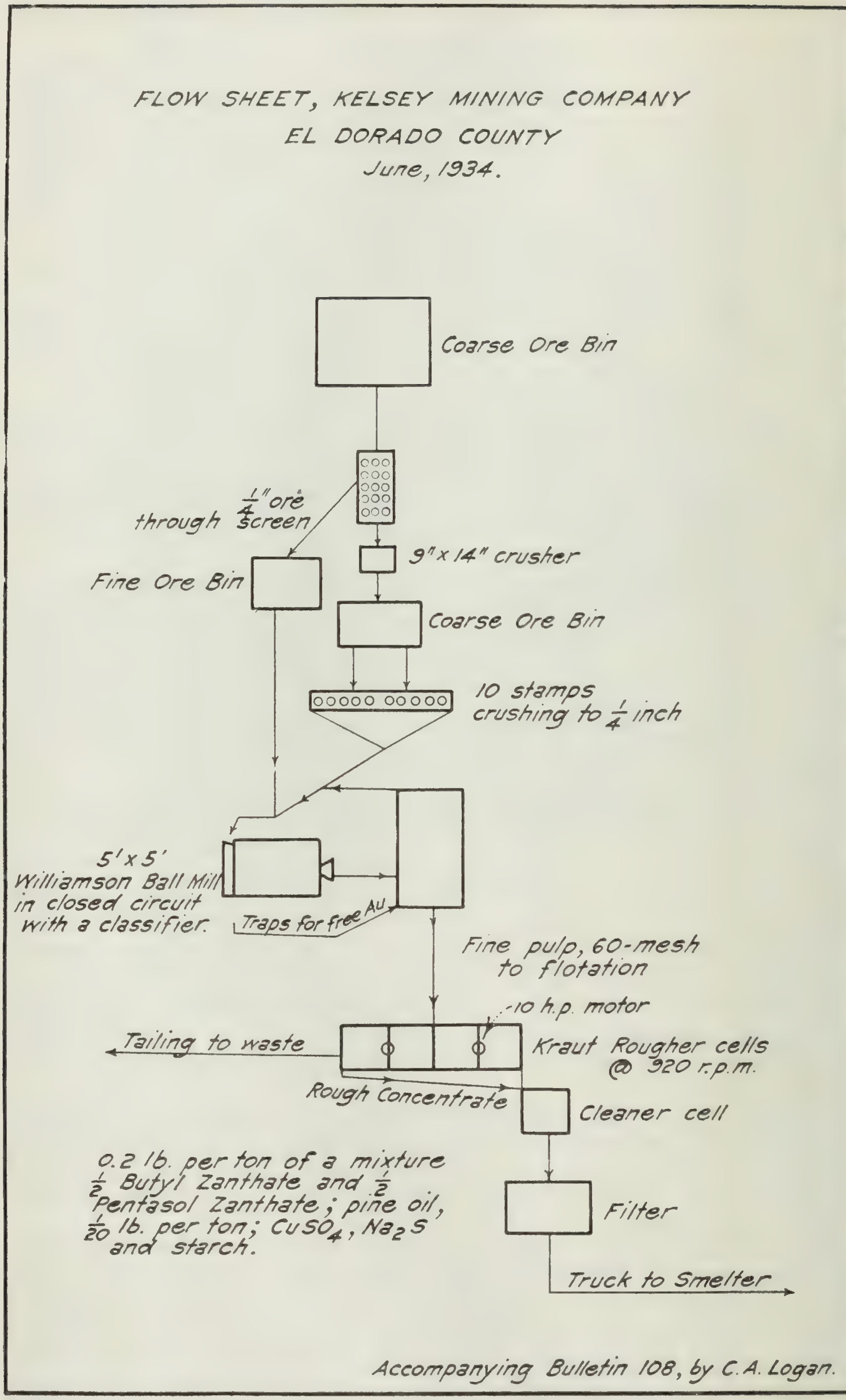
Kelsey Gold and Silver Mine. The claims of this group extend for nearly a mile along the contacts of narrow dikes of amphibolite schist and serpentine with the enclosing Mariposa slates, on the steep slope on the north side of South Fork of American River, starting ½ mile south of Kelsey. The work done up to June, 1934, was described in our Bulletin 108.

Since that time an upper adit, 300 ft. above the main adit, has been run 700 ft. north. The main adit, 1700 ft. long, has not been extended. Stoping is going on above the lower adit. An electric locomotive hauls trains of loaded cars to the mill which is crushing 40 to 45 tons a day. A shaft has been sunk 42 ft. at the mouth of main adit, and the 2 adits have been connected by a manway. The upper one is being advanced. The Lady claim on the hanging-wall side has been acquired.

The mill has been rebuilt, dispensing with the 10 stamps. A Telsmith gyratory crusher and Aurora jaw crusher furnish ¾-inch feed to a 5-ft. by 5-ft. Williamson ball mill crushing to 60 mesh, in closed circuit with a double classifier. A Pan-American jig takes pulp from the mill. The classifier overflow passes to 4 Kraut flotation cells run in pairs by 10-h.p. electric motors. Concentrate then is cleaned in 1 cell which returns its tailing to the 4 rougher cells. Pine oil, reagent 301 and zanthates Z 6 and Z 8 are used for flotation. A recovery of 90% is claimed with tailings running from 13¢ to 26¢ a ton. About 30% of gold is recovered free and the balance by smelting concentrate at Selby smelter.

About 15 men are employed, working 1 shift in the mine and 3 in the mill. Electric power is used throughout. So far a large sum raised from the sale of stock has been spent, but the average grade of material milled has not been high enough to permit calling it ore.

Lotus Bar Placer. This is on the South Fork of American River at Lotus, where a deposit of gravel accumulated on the south side of the stream. Several companies have been formed in the past few years to work here. The first was *Great Bend Mining Company, Limited,* which built a stationary washing plant using a trommel, sluices and a belt conveyor similar to those on bucket dredgers and employing a steam shovel for digging with trucks to haul gravel to the


FLOW SHEET, KELSEY MINING COMPANY
EL DORADO COUNTY
June, 1934.
Coarse Ore Bin
1/4" ore through screen
9" x 14" crusher
Fine Ore Bin
Coarse Ore Bin
10 stamps crushing to 1/4 inch
5' x 5' Williamson Ball Mill in closed circuit with a classifier.
Traps for free Au
Fine pulp, 60-mesh to flotation
10 h.p. motor
Tailing to waste
Kraut Rougher cells @ 920 r.p.m.
Rough Concentrate
Cleaner cell
0.2 lb. per ton of a mixture 1/2 Butyl Zanthate and 1/2 Pentasol Zanthate; pine oil, 1/20 lb. per ton; CuSO4, Na2S and starch.
Filter
Truck to Smelter
Accompanying Bulletin 108, by C. A. Logan.

washer. This plant was operated only a short time and apparently not at a profit. The company was succeeded by *Placers, Incorporated,* a Los Angeles concern, which at first brought in an elaborate screening and washing plant mounted on a heavy auto truck chassis. In April, 1935 they had given up the use of this. A Le Tourneau 'bulldozer' was then employed to strip the overburden, and the gravel was dug with a 1-cu. yd. gasoline shovel feeding directly to a small portable washing plant, which limited the capacity of operations. Later trucks were used to haul gravel. The washing plant was placed on a worked out piece of land where tailing storage space was available, and the plant could be moved by a tractor.

The deposit is about 15 ft. deep, consisting of up to 12 ft. of sandy overburden and 3 to 4 ft. of loose gravel with medium to coarse boulders, lying on rotten granodiorite bedrock.

Mammoth Mine. Between Weber Creek and American River about one mile east of their junction and eight miles northwest of Shingle Springs. It was worked in early days by Jasper Jurgens who is reported to have taken out a $10,000 'pocket' in 1860. The 'porphyry vein', 5 ft. wide and striking west, runs at nearly a right angle to the 'pocket' vein, which strikes northeast and dips west in gabbrodiorite. The 'porphyry vein' has been prospected by a crosscut 75 ft. long and a drift of 120 ft.

Lester F. Skinner, who leased the property in 1934, reported milling some of the dump material from the 'porphyry vein' with encouraging results. He used three 350-lb. stamps, run by a small gasoline engine.

Martinez Gold Mines Company (formerly *Hillside Group,* and later locations). West of Martinez Creek 4½ miles east of south of El Dorado, on road past the Union Mine. The claims cover 4500 ft. on the strike.

Since Bulletin 108 was published, work has been resumed and in May, 1937 when visited, 4 men were working of whom 2 were driving the lower adit south. This adit enters from the east and the various branching crosscuts and drifts partly prospect the Gold Reef, Martinez and Hillside No. 3 claims, the south face being about on the side-line between the 2 latter claims, south of the Gold Reef. These claims are on the east side of the Mariposa slate carrying the Mother Lode veins, near and upon the contact with the Calaveras formation. Rock coming from the face at time of visit was in part altered to carbonate showing mariposite and indicating interbedded igneous layers in the contact zone, but Mariposa slate is the most prominent in the exposures to the west and north. The south face is about 1400 ft. from the portal. On Gold Reef claim 600 ft. from the portal, a typical lens of slate-quartz ore 38 ft. long was opened in previous work. Grant Busick, president of the company, reports mining here 115 carloads of ore that yielded $4.12 a ton (old gold price). A winze was sunk 22 ft. below the adit here and is claimed to show 9 ft. of ore. About 90 ft. of backs remain above the adit, the rest of this ore having been mined from above, and is said to have yielded $10,000.

These adit workings, aggregating probably 2000 ft., are east of the 'bull quartz' vein and the slate above this adit level appears to be disturbed, with dip to the west. The ore was followed down from the hilltop along a series of breaks which faulted it northeast from 16 ft. to 30 ft.

The old 5-stamp mill has been sold and moved to the Crusader mine. There are several small buildings, one housing a Holt 4-cylinder engine which runs a 9 inch by 8 inch air compressor.

Melton Mine on Cosumnes River 2½ miles north of Grizzly Flat, had already been extensively worked in 1888, when it was described in Report VIII of the State Mineralogist. At that time it had 3 adits, the longest and lowest being 3000 ft. long and having a reported vertical depth of 500 ft. below the surface. Nine ore shoots had been found in the vein which strikes north and dips steeply west and which was stated to have an average width of about 3 ft. Evidently it lay idle for a long time after 1888 as it does not appear among the list of producers again until 10 years ago. Since that time, a number of companies have each worked at the property for a short time, and there has been an annual production of a few hundred tons of ore. The total reported for 7 years was less than 2500 tons, of an average gold content of nearly one-half ounce a ton.

The vein strikes nearly north and dips west in granodiorite. The ore carries sulphides of iron, lead, zinc, copper, antimony and arsenic and the bullion produced in the early work contained considerable silver. The concentrate amounted to 2% or more and yielded from $100 to $200 a ton in gold. In late years, the ore bodies found have been small.

The milling plant includes an Emco ball-mill, Dorr Duplex classifier, Denver unit flotation cell, 4 Fahrenwald and 4 Kraut flotation cells. The name of the operating company has lately (Feb. 15, 1938) been changed from *Miller Gold Mining Company* to *Cosumnes Mines, Inc.*

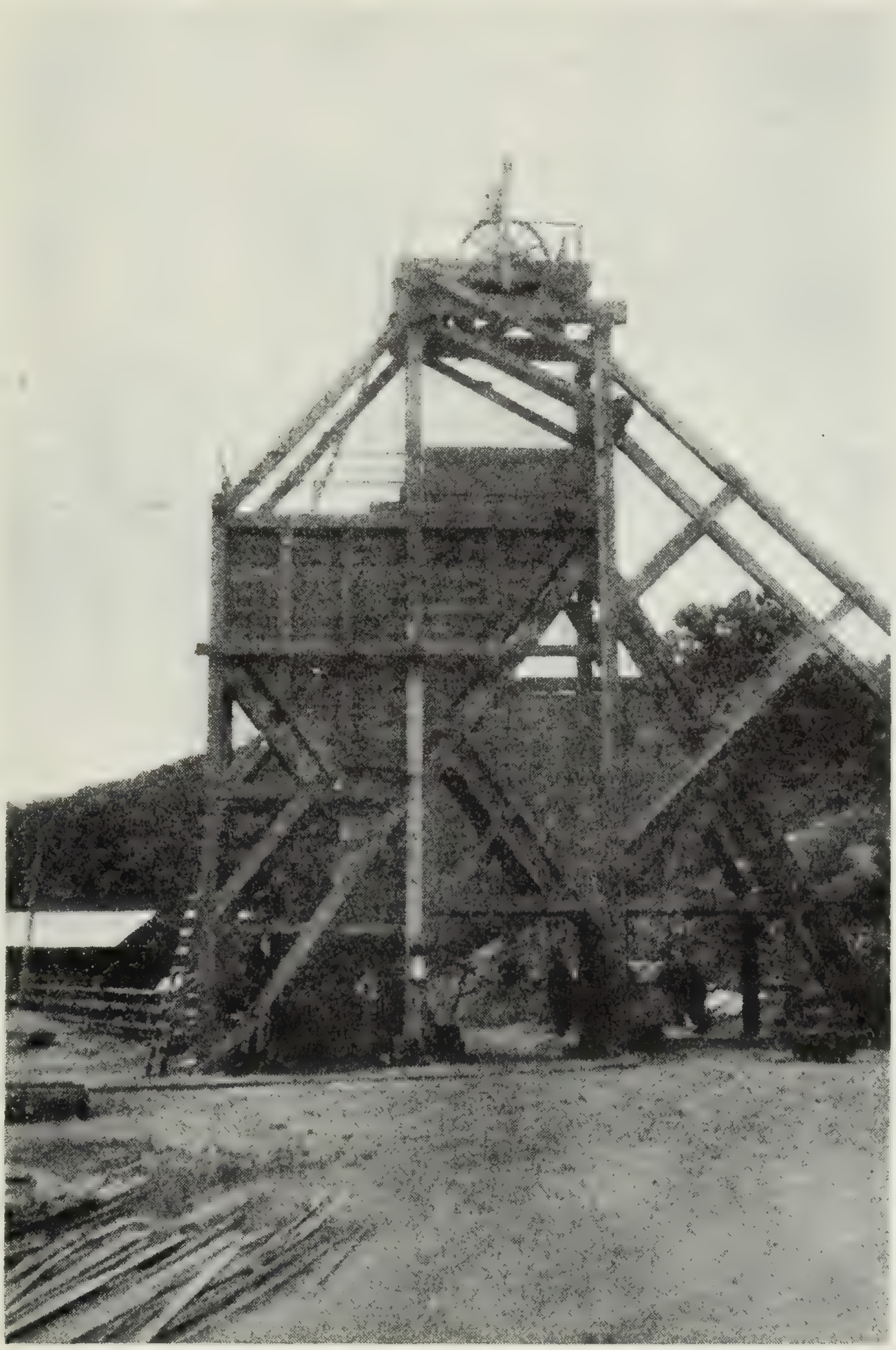
Mitchell Prospect. In SE¼ sec. 7, T. 10 N., R. 9 E., two miles northwest of Pine Hill Lookout. A quartz vein from 4 ft. to 10 ft. wide has been prospected on this and adjoining land owned by W. C. Wulff in sec. 8. A length of 200 ft. on the Mitchell land, where the vein is widest, is claimed to give encouraging assays in surface openings.

On the Wulff land, an old shallow adit about 150 ft. long was lagged up at time of visit, but the vein is stated to carry a fair gold content for a length of 110 ft., judging by assays and other tests mentioned by Wulff.

Montezuma Mine. This mine is now owned by *National Tunnel and Mines Co.* which is controlled jointly by *Utah-Apex Mining Co.* and *Anaconda Copper Mining Co.* The property is at Nashville on the Mother Lode highway 2 miles north of the Amador County line.

Since the publication of Bulletin 108, which described operations up to June, 1934, the Montezuma shaft has been sunk to 1540 ft. The 1300 ft. level was run 700 ft. and the 1500 ft. level 1275 ft. on the Montezuma vein. Although the vein appeared unchanged and was of

good width in these deeper levels, with no faults reported, it did not carry sufficient gold to make ore below a depth of 1225 ft. The 1500 level south drift was run 1050 ft. and besides prospecting the Montezuma vein, some 250 ft. of work was run looking for the Nashville (Havilah) vein below the bottom of the Havilah shaft.

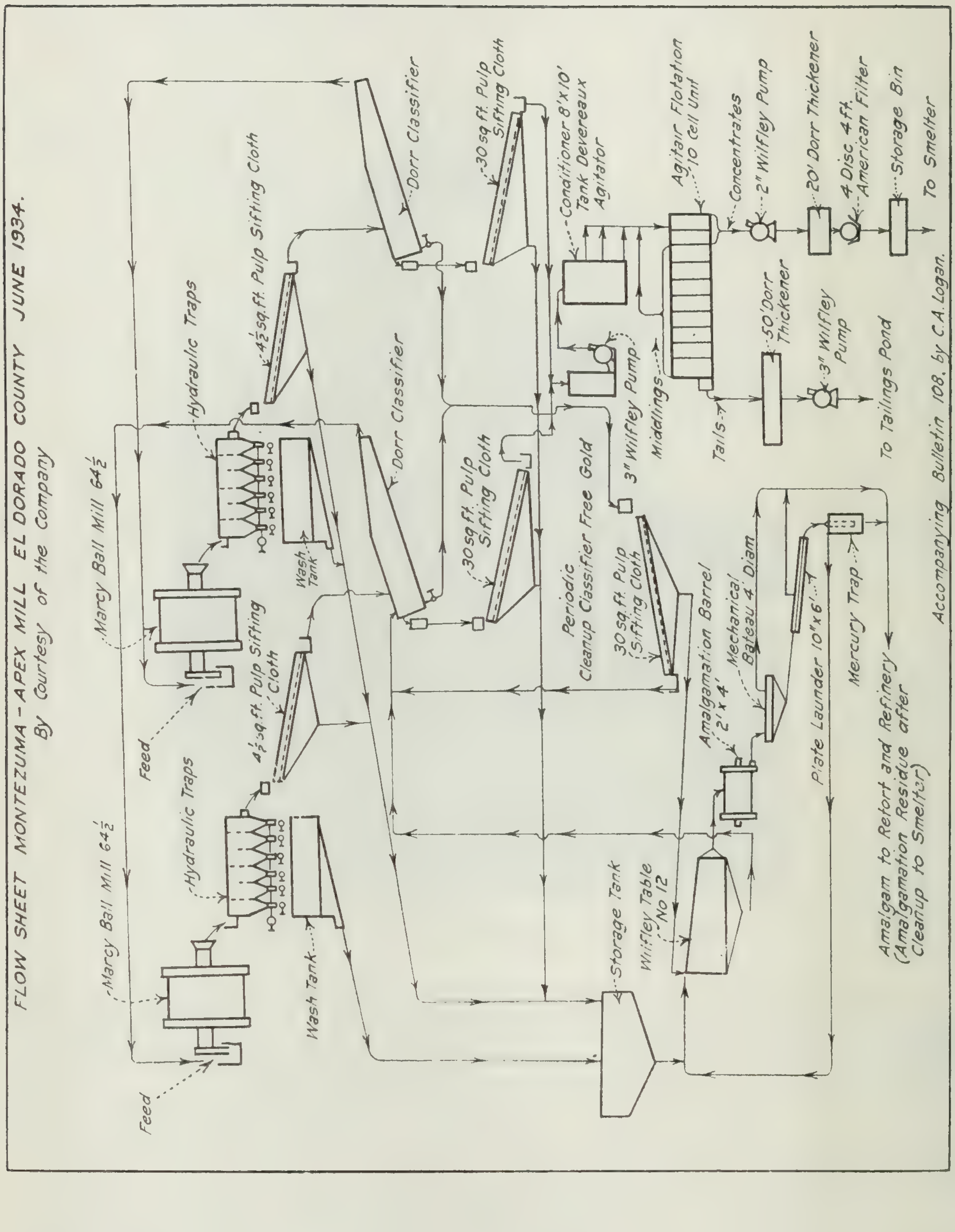


Headframe at Montezuma Mine, Nashville.

Milling of ore from the Montezuma was stopped July 10, 1936, but the mill was used until April, 1937, to crush ore from the Union Mine. Since the latter date, operations have been suspended pending a decision as to the advisability of further prospecting.

The occurrence of such lean zones is not at all unusual in Mother Lode mines and most of the successful ones have sunk through such zones into deeper ore bodies.

The Montezuma spur vein, entering the main footwall vein from the east side near the shaft, with a northwest strike, produced good ore between 900- and 1100-ft. levels. Below the latter level it became poorer, and was not found on the 1300- and 1500-ft. levels.



FLOW SHEET MONTEZUMA-APEX MILL EL DORADO COUNTY JUNE 1934.
By Courtesy of the Company

Accompanying Bulletin 108, by C.A. Logan.

Morey Mine adjoins Mt. Pleasant Mine on the north. A dozen or more shafts from 60 to 70 ft. deep have been sunk on 10 different small veins. Bunches of ore of good grade, six inches in average width and about 15 ft. long, have been extracted. The owner has a small mill nearby to which ore has been hauled.

Mormon Hill Mine. In sec. 3, T. 10 N., R. 9 E., 1⅓ miles north of Deer Valley road, and contains 80 acres. Dr. C. C. Long, R. 2, Box 24, Placerville, was in charge at time of last visit.

An incline was sunk in 1934 to an inclined depth of 110 ft. on a vein from 24 to 30 inches wide, striking N. 40° E. and dipping west. Drifts were run 40 ft. each way on the vein at 100-ft. level. Some low-grade ore from the workings and from an old dump was crushed in a 5-stamp mill with no concentrators. Later the small gasoline hoist was removed from this shaft to the site of some old Mexican workings, about 500 ft. southeast. Here a new incline was being sunk but had not yet bottomed the old workings at time of visit. In early days Mexican arrastres had been operated here on quartz outcrops near a branch of Weber Creek. Three men were employed at the time.

Power for the mill is supplied by a 15-h.p. semi-Diesel engine burning stove oil, and the hoist is run by an automobile engine.

Mount Pleasant Mine, a mile from the old town of Grizzly Flat, was the principal producer of the district. It covers 5156 ft. along the strike of a series of parallel veins in granodiorite near the contact with mica schist.

This mine is said to have been opened in 1851 but no record of its output before 1874 is available. From Oct. 20, 1874, to 1914, the output is claimed to have been $1,046,748 from 75,000 tons, but no statistics are available for many of the years when the mine was reported active. Details quoted by James D. Hague indicate that from July, 1881, to Sept. 30, 1887, a total of 46,000 tons yielded $643,348 gross, from which a profit of $170,603 was realized and $150,000 in dividends, equal to the entire capital stock, was paid. During the past 10 years very little work has been done and the reported production has been only a few hundred dollars a year. The old surface plant has been burned.

The veins dip vertically and strike from N. 15° E. to N. 39° E., a few degrees east of the zone in which they lie. The principal veins, their sizes and the extent of the development work done upon them, are as follows:

Name of vein	*Width*	*Length developed*	*Depth reached*
Earle	1 ft. to 18 ft.	400–800 ft.	1000 ft.
Mt. Pleasant	6 ft. to 18 ft.	225 ft.	260 ft.
McKane	1 ft. to 14 ft.	120 ft.	500 ft.
Charles	6 in. to 4 ft.	200 ft.	240 ft.

Most of the production came from the Earle vein, of which one-half the width is said to have been ore, and the balance filling and 'horses.' Stoping on this vein reached a depth of 850 ft.

Three shafts, 300, 600 and 1040 ft. deep respectively, were sunk, the deepest being 1220 ft. from the north end-line. Most of the prospecting was north of this shaft, the north drifts on the 10 levels varying from 300 to 1300 ft. long. Stopes were extended 180 ft. north and

from 100 ft. to 180 ft. south of this shaft. The veins pinch and swell and consist of banded or ribbon quartz with pyrite, galena and zinc-blende, and with some copper reported in the bottom level.

The mine formerly had a water-right and 4½ miles of ditch for taking water from a branch of Cosumnes River. A 10-stamp mill was used and power was furnished by steam.

No. 2 (Edmunds) Claim adjoins the Paul Friedman ranch, 1.2 miles north of Rescue. A ledge so far found to be broken up has produced some small 'pockets' in years past. At present being prospected by Cary Edmunds who has an adit 200 ft. long and has started another. He has mined possibly 100 tons of quartz. Width of vein averages two ft.

One Spot (Sailor Jack) Drift Mine. Spot Mining Company has been working the ground since early in 1933 under lease from El Dorado Irrigation District. The holding contains 90 acres in NE¼ sec. 18 and NW¼ sec. 17, T. 10 N., R. 12 E. between Camino and Newtown. Years ago about $40,000 is said to have been taken out of 160 ft. of buried channel, through an old adit 500 ft. long.

The present company began work 300 ft. from the portal of the old adit and ran 492 ft. mostly N. 12° W., diagonally and upstream in a secondary flow which had cut off the earlier productive channel worked by Sailor Jack and partners. They have also cut back across the later channel in search of the first, a total of 600 ft. more; and breasted out an area 15 ft. wide by 125 ft. long and 4 ft. deep of cemented mixed gravel and soft bedrock. Several raises have been put up, in one of which in May, 1936 white rhyolite ash was reported. This ash is known to be the capping of the earlier channel they are seeking. Two men are working.

In the past two years enough gold has been produced to pay running expenses. An average of $8 a cubic yard is claimed, the largest nugget weighing 3.42 oz. Troy. The gold ranges from 910 to 919 fine.

On the west side of the land another channel is reported, 21 ft. lower than the earliest one.

Pendelco (Funny Bug) Mine is in SE¼ sec. 5; T 10 N; R 10 E; 1200 ft. north of Weber Creek and 7½ miles by road west of Placerville. For several years, different lessees attempted to open this property and the production of a few ounces of gold has been reported annually since 1928 by H. H. Smith. When visited in 1929, two shafts were 50 ft. deep and another, caved, was 35 ft. Two veins had been prospected, one for nearly 170 ft. striking N. 15° E. and dipping 80° E; and showing a streak from 6 inches to 9 inches wide heavily charged with pyrite, chalcopyrite, specular hamatite, a little malachite and much iron oxide, at the bottom of one of the 50-ft. shafts. A shipment of 4 tons taken out between the surface and 35 ft. in depth in 1929 showed gold, copper, iron, antimony and arsenic. Zinc, lead and traces of molybdenum have since been reported.

The last operator, Pendelco Company (Ralph Penn) had a shaft 200 feet deep in October, 1937. This is on an angle of 73°-20′ and reported in ore to a depth of 117 ft. Below there the vein and

shaft are steeper, the latter being inclined at 83°-20′. No. 1 level is reported in ore for 117 ft. From this a crosscut was run 210 ft. to the second vein and a drift of 117 ft. was driven on this. On No. 2 level, a drift had been run 307 ft. north, of which about 266 ft. was on the hanging-wall side of the main vein and not exposing the full width of ore, but a width of 2 ft. to 50 ft. of vein material was claimed, with the best assays on the footwall.

The deposit is in fractures in augite diorite, which has granodiorite on both walls. Assays of gold and copper content of the main vein vary considerably, showing from a few dollars to over an ounce of gold in places, and from 1% to 10% or more of copper.

The equipment includes an air compressor with 50 h.p. motor and single-drum hoist with 25 h.p. motor, run by electric power from P. G. & E. Co. Eleven men were employed in October, 1937, but work has since been stopped. The owner was planning in August, 1938 to install milling machinery.

Pilot Hill Mining Company (*Boulder Placer Mine*). The company was working this old mine at Pilot Hill in May, 1936 but is reported to have suspended work since. Thirty acres of land, traversed by a remnant of old channel, was under lease. It had not been sufficiently prospected to give an accurate estimate of yardage. An average depth of 22 ft. was being worked in May but farther south the depth increased to 40 ft. The bank shows little washed gravel but much angular greenstone and rotten slate, with a few large quartz boulders.

At the time of visit, the plant was working two 8-hour shifts, handling about 400 cu. yd. in place each shift. A Diesel-operated shovel with 1¼-cu. yd. dipper was used for digging. Gravel was hauled under contract in four 2-cu. yd. auto trucks a short distance to the stationary washing plant, dumping from a ramp. The grizzley, with bars spaced 7½ inches apart, rejected 10% of the total in the form of heavy rock which was trucked away. The remainder, of which only 33% was fines, was handled by 115 ft. of 30-inch conveyor belt, a 25-ft. trommel (of which 8 ft. was screen and the balance scrubbing sections) and 240 sq. ft. of riffles. Sixty miners inches of water was purchased and brought to the plant in 3000 ft. of 8-inch pipe. A Kohler lighting plant was used.

The pay was spotted and was reported to vary from 13 cents to 60 cents a cubic yard. N. M. Gibson and J. C. Fay formed the company and had active charge of work.

Pleasant Valley Mine. An old mine about four miles northeast of Pleasant Valley between the forks of Clear Creek. It was last worked in the 1880's. In an old report (1896) a tunnel 480 ft. long is mentioned. The discovery shaft joins this tunnel at a depth of 110 ft. about 400 ft. from the tunnel portal. Thence a drift runs about 100 ft. on the vein to a winze 80 ft. deep from which some drifting was done. An air shaft 110 ft. deep also connects with the tunnel. The vein, reported to be 2½ ft. to 6 ft. wide, yielded some good ore in the early 1880's.

In 1935 several partners spent $7000 cleaning out the tunnel and prospecting the upper workings. They planned to buy the mill

building and equipment on the Black Gold and move it to the Pleasant Valley, but after hauling a little ore from the mine to the mill, the work on the mine was discontinued.

Poor Prospect. Wm. Poor, owner. In SW¼ sec. 12, T. 11 N., R. 10 E. A shaft has been sunk 60 ft. on a stringer lead in amphibolite schist surrounded by Mariposa slate. The open cut from the floor of which the shaft was sunk is 37 ft. wide and is said to assay well for a width of 28 ft. Quartz stringers dipping and striking with the schistosity of the schist are said to carry most of the gold. In the bottom of the shaft, which was nearly full of water, it is claimed there is 2 ft. of solid quartz on the hanging wall side and 1½ ft. of it on the footwall side with 'stratified slate' between. The hanging-wall section there is said to prospect well. The quartz stringers at the surface strike N. 15° W. and dip east nearly vertically. Gold concentration may have been localized by cross stringers and small flat-dipping slips from the west, though this could not be checked. Thirty feet west of the shaft one of the typical 'bull quartz' veins of the Mother Lode strikes N. 30° W. The shaft is in a section of vein about 150 ft. long between two transverse gullies. It makes 80 g.p.m. of water.

Between 200 and 300 tons of ore from this prospect is reported to have been milled at the Veerkamp property during the time Gilbert Chisholm had a lease (early 1938). The owner has no definite record of what this yielded. Idle July 8, 1938. The only equipment at that time was a small gasoline engine and pump. An electric power line now being built will pass close to the shaft. Water is available in the Georgetown ditch 2000 ft. distant.

Pyramid Mine is 4.4 miles west of north of Shingle Springs by road. The Pyramid claim covers about 3500 ft. in length on the strike and contains 23.65 acres, and mineral rights on surrounding land have also been under option by the operators. Several companies in succession have had the property in late years. The last of these, *Gold Reserve Mine,* for over 30 months mined and milled ore, a large part of which had been developed by their predecessors. The mill was shut down late in 1936 and since then prospecting has been going on, but this work was stopped early in 1937.

The mine was opened through an inclined shaft on the vein at an angle of 63° for 525 ft. then at 58° to the 700-ft. level. On No. 2 level (165 ft. deep on dip) where former operators had drifted 62 ft. south and 225 ft. north, a length of 185 ft. was claimed to be ore. On the third level, 100 ft. of drifting was done and on the fourth drifts were run 100 ft. each way. Level No. 5 was run about 140 ft. south and 300 ft. north from the shaft crosscut, but on the north the vein was low grade. In March, 1936, the last operators completed sinking the shaft to 818 ft. The last work was done on the 5th, 7th, and 8th levels, on the '49' vein, about 70 ft. from the main vein which had supplied ore above. In these lower workings an ore shoot 140 ft. long was claimed and the average width stoped was 6 ft., although from 12 ft. to 15 ft. was mined in places. This was low-grade sulphide ore. The main vein in the upper levels was also wide.

The mine is in an area of amphibolite schist, with gabbrodiorite on the west. Considerable of the carbonate-silica mixture stained by mariposite, a rock commonly called ankerite, has been developed by alteration of the amphibolite, and this forms one wall in places. The vein strikes west of north and dips east, and the width varies from a few feet to over 20 ft. with a maximum width of 30 ft. in the massive outcrop of quartz from which the mine was named. The main vein does not run far south of this outcrop, but is broken and irregular in the south drifts from the present shaft, which is some distance from the old workings. The early operators claimed an ore shoot 500 ft. long existed at their old workings. The second vein is thought to join the Pyramid near the north end of claim. Because of the gold being associated with sulphides, and the ore being of only medium or low grade, the early work was not successful.

Headframe and mill building at Pyramid (Gold Reserve) Mine, north of Shingle Springs.

The cyanide process as applied here by Vandercook proved a success and the increase in the price of gold was an added inducement to work the mine. A recovery of from 96½% to 97.2% was claimed during the last work.

Primary crushing was done with a Traylor gyratory crusher which reduced ore to 1 inch. The 6-ft. by 6-ft. ball mill in circuit with a Dorr duplex drag classifier ground 98% of ore to pass 65 mesh. The pulp passed to two agitators, 14 ft. by 16 ft. Eight hours elapsed from the time ore entered the ball mill to the completion of agitation. It is claimed that most of the gold was in the precipitate bags within two hours after contact with solution. A special feature of the Vandercook process is the mercuric generator, a tank in which aerated cyanide solution is passed over mercury, forming, according to the inventor, mercuric cyanide which is claimed to shorten the time of treatment and to make possible the treatment of complex ores containing sulphides which would foul ordinary cyanide solution.

The cyanide plant (not including mill building and crushing equipment) is stated to have cost $15,000. It consisted of the following items:

2 thickener tanks, each 50,000 gal. capacity.

2 agitator tanks, each 25,000 gal. capacity.

1 clarifier, sump and stock tanks of 10,000 gal. capacity each.

2 generator tanks of 2000 gal. capacity each.

Oregon pine lumber was used in making all tanks.

3 diaphragm pumps, 3 small pumps, 3 five-h.p. motors, main shaft drive and one 25-h.p. motor. A Merrill-Crowe precipitating unit of 3 iron tanks 4 ft. by 4 ft. by 15 ft. with bag collectors was used. Tank foundations, pipe and connections were included in the above reported cost.

In treating 112 tons of ore daily, about 75 lb. of sodium cyanide and 24 lb. of zinc dust were used. About 20 lb. of mercury was used every 3 months in the mercuric generators. Fresh water consumption was 8000 gallons daily. An operating cost of 70 cents a ton of ore crushed, exclusive of interest and depreciation, was claimed for the cyanide plant.

Since the above was written, F. J. Kaeser, Rhoads Grimshaw, and associates, who held the first lease, have completed the purchase of the mine and have resumed possession. The cyanide plant and part of the mining equipment have been sold and were being removed at the time of last visit, March 25, 1938. Ten stamps and a concentrating table have been erected in the mill-building, and crushing of ore from the 200-ft. level north of the shaft has been started. Three lessees are working underground and the owners are operating the mill. They claim there is considerable oxidized ore between the surface and 200-ft. level that they think is amenable to stamp-milling.

The lower levels are under water and the owners have no plans now for resuming work in that part of the mine. For the present, the 200-ft. level will be advanced on the Pyramid vein northward in search of 2 intersections which are believed to exist where cross veins from the east and west meet the main vein. The 800-ft. level was run 234 ft. south in the last work done by the Gold Reserve management. This level is said to have encountered a fault crossing the vein and dipping N. 70°.

The mine is equipped with a 125-h.p. single-drum hoist of 800 ft. depth capacity, and an Ingersoll Rand air compressor run by a 75-h.p. motor. There are a shop building, boarding house, and smaller buildings on the land.

Richelieu Prospect is the next claim north of Golden Fleece claim of the Church Mine, and is on Martinez Creek. There is an old shaft of unknown depth on the slope west of the creek, and on the same side an adit was run from near the creek level. This work was done while the Church mine was active, and a small lot of low-grade ore is said to have been crushed at the Church mill. In 1932 W. A. McCoy and associates began work in the adit and extended it to 275 ft. in length. For 180 ft. the adit crosses Mariposa slate with quartz stringers, and gold in small quantities is reported all through this width. On the

west of this there is a soft gouge 3 ft. thick which runs badly when wet. For 40 ft. west of gouge, the adit is in diorite porphyry and work stopped in this. Idle in May, 1937.

Robert Veerkamp Mine is in the NW$\frac{1}{4}$ sec. 33, T. 12 N., R. 10 E., about 1 mile west of Garden Valley. It was mentioned in Bulletin 108 as a prospect before any work except shallow pocket-hunting had been done upon it, and the writer expressed the belief that the gold found in the loose, red soil probably came from stringers or disseminated sulphides in the upper, decomposed part of a long, narrow basic dike which here runs northwest along the west side of the Mother Lode, about a mile west of the main vein system. This has been confirmed by work done on the property during the past few years, although the quartz veins which formerly outcropped have been partly removed in mining and probably contributed some gold. One of these veins at the surface was wide and of low-grade white quartz. It strikes N. 25° W., dips east and is faulted to the west, looking north, by a smaller vein of bluish quartz striking N. 15° E. The decomposed dike forming the red soil on the east side of the junction of the two veins gave way at the shallow depth reached to oxidized ore.

The Bradley interests took the property early in 1933. Some ore was mined from an open cut and hauled to the Beebe mill at Georgetown. They also ran an adit about 400 ft. into the hillside, but evidently did not reach the ore mined later. When they gave up their option, the *Spanish Gold Quartz Syndicate* (a Canadian company) was formed to operate the prospect. This company was soon succeeded by *The Gold Company, Limited,* also Canadian, under the same management.

They ran an adit from the north side of the hill which showed the best prospect. Near the portal, a pocket containing about $5,000 was found in October, 1935. The adit was run nearly south through the hill at a depth of only 37 ft. A shaft was sunk to a depth of 180 ft. and levels were turned at depths of 60 ft. and 97 ft. The 60-ft. level is reported to have been run 1200 ft. and the 97-ft. level 1000 ft. but the mine was closed at the time of last visit and this could not be checked. Oxidized ore was mined out above the 60-ft. level. This ore is reported to have been worked for a width of 27 ft. in places and assays of some of it are claimed to have indicated $12 a ton. Various methods of treatment, including the use of Huntington, Hadsell and Ellis mills, ball mill and flotation, and cyanidation were tried but it was stated that satisfactory recovery could not be made. The company quit early in 1937 and much of the equipment has since been removed. About $33,000 production was reported in 1936, and a little ore was milled early in 1937. Some small equipment, 3 buildings and cyanide tanks remain.

Along the strike of the dike, several hundred feet N. 25° W. from the shaft, an open pit was dug in the dike and considerable oxidized material was milled. Assays up to $4 a ton are reported here, the gold occurring in seams which occasionally show some quartz.

Rose Kimberly Mine. In secs. 10 and 11, T. 10 N., R. 9 E., 1$\frac{3}{4}$ miles north of Rescue. The only recorded production was made in 1895. So

far as can be learned, little work has been done since until the present lessees, H. Marsh, Henry Snyder and Alfredo Rodriguez started reopening and unwatering on Apr. 12, 1938. When visited July 7, water had been removed to the 120 ft. level, which was open, and the shaft had been retimbered to that depth. It is reported to extend to an inclined depth of 220 ft. Levels were turned at 60 ft., 120 ft. and 220 ft. The 60-ft. level is caved, and 120-ft. level is open on the northwest its entire length, about 300 ft. Here the vein takes the form of lenses one 40 ft. long by 20 inches in average thickness; the other separated from the first by 120 ft. is 55 ft. long with a thickness of 2 ft. at the face. So far as could be judged, both walls are gabbro. The quartz shows some galena, pyrite and chalcopyrite with some brecciated fragments of country rock included. In places, a narrow band of iron sulphide occurs in the adjacent wall rock. Two samples stated to come from this level gave assays of $5 and $1 a ton in gold, respectively. No stoping was done from the 120-ft. level and part of the rock broken in drifting still lay on the floor. The drift on the 60-ft. level was caved; the small amount of rock crushed in 1895 probably came from there.

Another vein a little west of the above, strikes N. 83° E. A shallow shaft on it was being cleaned out at time of visit and this was claimed to show a width of 1½ ft. to 2 ft. of more promising quartz than the first vein.

Equipment included a small pump, hoist and 2 gasoline engines.

Rozecrans Mine is 1½ miles northwest of Garden Valley, adjoining the Taylor Mine on the southeast. *Lode Development Co.,* Box N, Auburn, is the lessee. This old claim was worked previous to 1888, and the operations then were described in the 8th Report of the State Mineralogist. The work done was in the same shaft lately reopened by the present lessee. This is nearly midway of the claim. Another shaft was sunk near the north end-line but details of this are lacking. A 10-stamp mill was operated for a short time about 1888 on ore reported as yielding over $10 a ton, with an estimated output of $21,000.

The shaft now in use is 350 ft. deep, the first 100 ft. being vertical and balance on an incline of 60°. The vein occurs in amphibolite schist which has a width at the surface of about 250 ft. and Mariposa slates lie on both sides. The vein is for the most part frozen or has little gouge, and its average width is reported to be 3½ ft. It dips west and is west of the Taylor vein. The quartz occurs in irregular shaped bodies. The hard walls permit mining without timber. The old work included the shaft to a depth of 200 ft. and levels at 100, 130, and 200 ft. with several hundred feet of drifts. The present company, besides deepening the shaft and reclaiming the upper levels ran the 250-ft. level 415 ft. north and 160 ft. south; and ran the 350-ft. level 130 ft. north and 180 ft. south. On the 130-ft. level, a lens of ore has been mined on each side of the shaft. On the 200-ft. level, one lens was mined on the south side and two on the north, while on the 250-ft. level two ore bodies both north of the shaft are being worked. These are reported to be 125 ft. to 150 ft. long each. This work on the west vein is near the west contact of the amphibolite schist and slate.

A crosscut was run 165 ft. east from the shaft on the 100-ft. level through the slate stringer lead of the Taylor vein. On the 130-ft. level,

100 ft. of work was done also on the Taylor vein, but neither of these revealed ore.

The ore is ground in a 6 ft. by 6 ft. grid-type ball mill which discharges to a Bendelari diaphragm jig and a double rake classifier. The jig is said to catch nearly all pyrite and 80% of the gold. Overflow from classifier then goes to a conditioning tank where reagents are added, and to 5 Fagergren flotation cells, a Dorr thickener and Oliver filter. The jig product is ground in 500-lb. batches for 24 hours, then 25 lb. mercury is added and grinding is continued 2 hours longer. Soda ash, Zanthate 301 and cresylic acid are used in flotation. Pyrite is practically the only sulphide found and 80% of the gold is free. The mill has a capacity of 100 tons in 24 hours but is being operated only 8 hours daily at present (July 20, 1938).

Electricity is used throughout. Two compressors are run by 125-h.p. and 50-h.p. motors and the hoist by a 50-h.p. motor. Thirty men are employed. Work began in August, 1936 and the mill has been running 11 months.

Mill at Rozecrans Mine near Garden Valley.

Shumway Prospect is about ¾ mile south of Alhambra Mine, and is also being prospected by *Alhambra-Shumway Mining Company.* There is a shaft 100 ft. deep, and at present 2 men are advancing a crosscut adit which is now (July, 1938) 300 ft. long, and will be 150 ft. below the outcrop at the shaft. No discovery of ore has been reported here yet by the present company. A portable compressor and air drill are the only equipment.

Sliger Mine, a mile west of Spanish Dry Diggings, was found in 1864 and is claimed to have made a production of about $225,000 to a depth of 300 ft., though no definite record of this remains.

It had been lying idle a long time when it was reopened in 1922 by *Sliger Gold Mining Company.* The operations from then until July, 1934, by this company and its successor, *Middle Fork Gold Mining Company,* were described in Bulletin 108. The latter company continued work until May 10, 1937, when the mine was closed pending financing of further development work. Over 80,000 tons of good ore was produced and milled in four years, 1932 to 1935 inclusive.

On August 31, 1937, *Mountain Copper Company, Ltd.,* took over the lease on the mine. They sank the shaft 350 ft., reaching a depth of 1350 ft. About 500 ft. of drifting and 1500 ft. of diamond drilling was done. Early in 1938 this company gave up its option.

In June, 1938, *Middle Fork Gold Mining Company* resumed work with a crew of 40 men. C. W. Plumb is superintendent. Electric power has since been supplied, the crew has been increased to 65 men and production at the rate of 100 tons a day has been reported.

The mine is at a fault contact with black slate on the footwall and ankerite and serpentine, followed by a gabbro dike on the hanging wall, all enclosed in amphibolite schist. On the 350-ft. and 500-ft. levels, the only ones examined by the writer, crosscuts were run through ankerite or similar mixed carbonate rock. The principal orebody seen was on the footwall side and is highly silicified, with some carbonates, and is thickly impregnated with fine disseminated crystals of sulphide, mostly pyrite. It had no definite wall but merged into low grade rock. Two classes of ore, called black slate or schist ore and grey schist ore were distinguished. Superficially the appearance was that of a replacement of a fine-grained rock. The width of ore here varied from 14 inches to 19 ft. Most of the gold is in the sulphides which make up 3.7% of the ore. On the 600-ft. level the ore was reported to be 32 ft. wide.

L. C. Raymond, geologist for Mountain Copper Company, believes that the ore-forming solutions rose along different favorable bands in the slate series to the thrust fault zone, where they spread out forming orebodies. The occurrence of several ore shoots at different levels along the fault zone in such a case would give the appearance of post-mineral faulting, although actually the only post-mineral faults were small horizontal offsets.

The stamp-mill first used was replaced by 2 ball-mills, flotation and gravity concentration. Two-stage crushing with Blake and Symonds crushers is used ahead of the ball-mills, which work in closed circuit with Dorr rake classifiers. From the mill, pulp passes over a Deister Overstrom concentrator which saves 75% to 80% of the gold in a high grade concentrator. The table tailing is sent to a conditioner and is treated by flotation in 6 Kraut rougher cells and 2 cleaner cells. Concentrate hauled by truck to Selby smelter.

Solari Tunnel Mine. First located as part of the Ventura Mine in Sec. 20, T. 10 N., R. 12 E., but in 1935 leased to Paul Alexander and Flavel Atkinsen, who were extending an adit then 351 ft. long. They were prospecting for the extension of the bench gravel found in the Black Gold.

Tiedemann, Kenna et al. Mines (*Two Channel Mine*) lie eight miles northeast of Georgetown. They were worked both by drift mining and hydraulicking in the 1890's and were described in Report XIII of the State Mineralogist, 1895-1896. Under the name of Two Channel Mine, production was reported until 1902. The holdings extend 3¼ miles southeast from Mount Gregory to and including the Tiedemann Mine in sec. 34, T. 13 N., R. 11 E. Two channels were found, called white and blue channels which were believed to be upstream portions of similar channels on the Forest Hill divide in Placer County. The former operators worked hydraulic pits on the Tiedemann, where the bank was 20 ft. high, with 10 ft. of gravel, and they also ran adits for drift mining. On the Kentucky Flat, a hydraulic pit was opened on the white channel, with a bank 25 ft. high of which from two ft. to six ft. was gravel, and drift mining was also carried on through an adit. On the Kenna and Morgan both channels were worked—the white channel by hydraulicking and blue channel by drift mining through an adit with breasts 60 ft. wide and 3½ ft. high. This blue gravel was cemented and was crushed in a 10-stamp mill.

In 1902, the following workings were reported at the various mines then held by *Two Channel Mining Company:*

Amelia, sec. 9, T. 13 N., R. 11 E. Adit 600 ft.
Kenna & Morgan, sec. 15, T. 13 N., R. 11 E. Adit 1500 ft. Breast 100 to 200 ft.
Kentucky Flat, sec. 22, T. 13 N., R. 11 E. Adit 625 ft. Shaft 80 ft. Breast 100 ft.
Novis, sec. 9, T. 13 N., R. 11 E. Adit 600 ft.
Tiedemann, sec. 34, T. 13 N., R. 11 E. Adit 1000 ft.

There were also hydraulic pits with areas of two acres or more each on the Tiedemann and Kentucky Flat, and some smaller ones. No reports appeared on the properties after 1902 and they had been idle for years when work was started on the *Tiedemann Mine* by *Century Mining Company* in 1932, under lease covering most of the holdings of the old company. The south end of the Tiedemann has since been prospected and mined through two main adits each 300 ft. long, with side drifts. They report a white quartz channel 1000 ft. wide, with gravel up to 14 ft. thick. Substantial production was made, judging by a suit brought against the company early in 1934 for royalties and rent alleged due.

The *Kentucky Flat* mine was worked in 1933 by C. B. Wooster.

Union (*Springfield*) *Mine.* Since Bulletin 108 of this division was published, the work started by *Gold Fields American Development Company* has been suspended, the mine was turned over to *Montezuma Apex Mining Company,* and turned back to the owners in April, 1937. During their lease, the latter company mined some ore which was hauled to their mill on the Montezuma mine and gave good returns.

The Springfield property lies in the Mariposa slates of the Mother Lode 2½ miles south of east of El Dorado. It was the center of a rich and populous placer-mining district of early days called Aurum City. Prof. Silliman, a noted mining authority of that time, was attracted by the rich ore first worked in arrastres here and induced friends to finance quartz mining. A pay-shoot north of the Union shaft is said to have yielded $450,000 from 15,000 tons of ore mined before 1868, but in spite of this the project failed and the property

lay idle until Hayward and Hobart purchased it. They operated it as the Springfield Mine until about 1887. They had a mill of fifteen 600-lb. stamps with a capacity of 26 tons a day. After an idleness of about 10 years, *Union Gold Mining Company* began work and a 30-stamp mill was built. In 1897, a production of $36,000 was reported, but thereafter only estimates of production were made public. These indicated that from 20,000 to 40,000 tons of ore was crushed annually, yielding from $5 to $7 a ton. In 1909, the last year for which any figures are at hand, 12,000 tons yielded a little over $5 a ton. The total production, although often claimed to be greater than from any other mine in the county is not definitely known.

Some of the old stopes partially checked by the last operators were found to be much smaller than indicated on a map which purported to show tonnages and gold content. It appears that both tonnages and gold production were less than claimed. For example, the Poundstone stopes, shown on the map as having a combined length of 400 ft. between the 500-ft. and 1300-ft. levels mostly north of the Springfield shaft, and claimed to have yielded $2,200,000 from 85,000 tons of ore, were found to have a length of only 100 ft.

The main veins, of which the Poundstone (East Gouge) vein has been the most important, follow the strike of the Mother Lode, north of northeast. They are linked by a series of lesser veins striking northeast. Of the latter, the Klondyke vein system is typical. This vein was found in 1898 by W. A. McCoy during the first forenoon after his employment by Harpending (then manager) to prospect for more ore. McCoy states this vein was only from 4 inches to 5 inches wide at the outcrop but of very good grade. It contained two ore shoots.

The Springfield 2-compartment vertical shaft had been sunk 1640 ft. by Hayward and Hobart. It was sunk to 1986 ft. vertical depth, with 3 compartments below 1600 ft., by Gold Fields American Development Co. This shaft is 320 ft. east of the East Gouge (Poundstone or hanging wall) vein, passing through it at 1200 ft. depth and cutting the west gouge (McCosmic) vein about 60 ft. above the 1600-ft. level. The veins steepen in the lowest workings and are claimed to join in the bottom. The shaft left the ''hard slate'' at 1975 ft. entering softer slate. The only work done on the deepest level, called 2000-ft. level, was a crosscut 28 ft. which showed 18 ft. of vein material with 4 in. to 6 in. of gouge on the footwall.

Only three small ore shoots were found in the recent work. On the 1800-ft. level, a crosscut 56 ft. west to the McCosmic vein struck ore which proved to be 35 ft. long, 6 ft. thick and 120 ft. high. Two other smaller bodies, called the 810 and 1210 ore shoots were also stoped, and the ore was hauled by truck to the Montezuma Apex mill. A total of about 35,000 tons was crushed in 1936 and 1937. Some of this, from the small ore-shoots mentioned, was of satisfactory grade; the average yield in 1936 was sufficient to have permitted operation at a profit if enough ore had been found. Concentrate formed 2% to 3% of ore, and carried about 35% of the gold saved. A typical lot carried about 3 oz. gold and 1 oz. silver a ton. Bullion carried 822 parts gold and 178 parts silver in 1000.

Besides the 21,000 feet of workings run by previous operators, the last two companies did the following work:

On the 1600-ft. level, 275 ft. north, 600 ft. east and 50 ft. north (mostly by Montezuma Apex Mg. Co.), 75 ft. south. On 1800-ft. level a crosscut 56 ft. to McCosmic vein and some drifting and stoping on it. On 2000-ft. level, a crosscut 28 ft.

On the 1200-ft. level, a total of 1575 ft. of old workings was reclaimed. The old 1000-ft. level was opened for 175 ft. from Springfield shaft and a new 1000-ft. sub-level was run 125 ft. The 800-ft. level was re-opened for 1000 ft. north of Springfield shaft to a raise and thence to a connection with the North Shoot shaft.

The number of veins exploited in the old workings is indicated by the following list of stopes:

Poundstone stopes from 500 ft. to 1300 ft. in depth, mostly north of Springfield shaft. (See ante.)

Union Gold Mg. Co. stopes between 1000-ft. and 1300-ft. levels, south of Springfield shaft, from shaft on East Gouge vein; claimed output, 17,500 tons of $8 ore.

Big Cut and Mexican stopes, from veins of the same names, between 800-ft. level and surface; mostly near surface. North shoot shaft workings are 1150 ft. N. 15° E. of Springfield shaft. The Klondyke north shoot was worked from this.

Clement shaft is about 950 ft. north of Springfield shaft and here McCosmic stopes were claimed to have yielded 50,000 tons of $25 ore.

The Klondyke shaft on Klondyke vein about 375 ft. east of Clement shaft, opened the original Klondyke ore shoot which was worked 400 ft. deep, 60 ft. to 100 ft. long and 3 ft. thick. It is claimed to have yielded 10,000 tons of $20 ore.

The Poundstone vein has been explored for 1400 ft. on the strike; Clement vein 1000 ft. on strike and Klondyke vein 550 ft.

All equipment except the hoist has been removed from the Springfield shaft.

U. S. Grant (*New Deal*) *Mine* is on an agricultural patent owned by John Sellick and J. A. Sackett, lying north of Mt. Danaher Ranger Station, nine miles east of Placerville. It is leased to Sackett and W. B. Nicholls.

This old mine is said to have had a 10-stamp mill in the 1870's, but no record remains of the production, if any. There is an old shaft, depth unknown, but probably not over 100 ft. A crosscut adit reaches the vein in 100 ft. and from there drifts had been run northeast and northwest 400 ft. and south 200 ft. on the vein. Two ore shoots are claimed. The vein varies from 8 inches to 44 inches wide. Some recent mill tests yielded $7 a ton. The country rock is of the Calaveras formation.

A Brunius muller-mill was being used for crushing. It has two shoes of 2½-inch steel, 2 ft. by 2½ ft. and weighing 1200 lb. each. They are run at 27 strokes a minute through an eccentric with 30-inch stroke. These mullers work in a wooden box 6 ft. by 6 ft. and 4 ft. high, paved with thick blocks of Rocklin granite. It is claimed the mill will crush 6 tons in 8 hours to 32 mesh, discharging pulp at a height of three inches upon amalgamated plates. A small concentrator saves sulphides. An auto engine is used for power. There is a 6 in.

by 6 in. compressor run by a 12-h.p. gasoline engine. Two or three men were working in May, 1936.

Vandalia Mine. This old mine, 4½ miles southwest of Shingle Springs between the Crystal and Big Canyon mines, is said to have been located in 1885. In 1888 it had a 5-stamp mill which was crushing 14 tons of ore a day. The ore was described as "partly honeycombed quartz and partly very heavily sulphuretted rock." Sulphide formed 5% of the ore and was saved on Frue vanners. After 1888, when most of the early work was done, the mine was reported idle in 1890 and 1894. In 1900, John Rosenfelds Sons produced about $10,000 with a cyanide plant. Since then, many attempts have been made to operate it. The extent of openings and amount of tailing indicate that considerable rock was mined and milled, but there are no available records of output except for about 50 tons of $5 ore milled in 1926.

The geology in general is similar to that of numerous sulphide deposits in the county in which amphibolite schist and the rocks interbedded with it have been silicified and impregnated with pyrite which is more or less auriferous. The oxidized, upper parts of the bodies rich in sulphide yielded the ore of early days. Two ore shoots 20 ft. thick and 50 ft. and 100 ft. long respectively, were reported. The lowest of the old adits reached the fresh sulphide at the bottom of the oxidized zone, and this has evidently not yielded enough gold, so far as opened, to pay a profit.

In 1937, Page Consolidated Mining Company completed the erection of a milling and cyanide plant of 150 tons capacity. It included a Hardinge conical mill, agitators, thickeners, clarifier, etc. Evidently insufficient underground work was done to learn whether or not such a plant was justified, before building. Only a few short runs were made when work was stopped. When visited in March 1938, the mine and plant were idle.

Ventura Mine. In sec. 20, T. 10 N., R. 12 E., in Newtown district, on the north side of a lava-covered ridge running west between Pleasant Valley and Webber Creek. Surface workings in early days on this side of the ridge were extensive and profitable. The recent work has consisted of driving an adit south through the ridge in search of a channel, and also to reach the unworked part of the bench deposit believed to remain on the Black Gold. At the time of visit, the adit was 935 ft. long and it was thought that the Black Gold ground would be entered in a short time.

This adit was in volcanic ash and no bedrock was seen. There was some fine, tight gravel at the face which was dipping at an angle that would soon carry it below the adit level. No pay was reported to have been found up to that point in the adit, and there was no water in evidence. The ground required blasting. Drift sets and tight lagging were used. Three men were employed.

White Owl Claim is in the SW¼ of the SE¼ sec. 23, T. 11 N., R. 11 E., near Red Bird Creek and about 1 mile south of Mosquito.

An inclined shaft has been sunk 65 ft. on a fissure from 18 inches to 3 ft. wide in which an average of 2 inches of quartz has been yielding

a reported average of $65 a ton. The walls are granodiorite and the vein strikes northeast.

There is a 2-ton Gibson mill on the claim. Mrs. Ethel Sperry and D. Chalmers, Box 342, Placerville, have been operating the claim recently.

Winton and Threlkel Prospect. This adjoins the Zantgraf Mine on the northwest and is believed to be on the same vein. It is on land patented for agriculture and belonging to Olivia Smythe and M. L. Winton et al.; in SE¼ of SE¼ sec. 17, T. 11 N., R. 8 E.

The fissure (in which a width of about 1 ft. of solid quartz and several small quartz stringers occur) has a width of 52 inches. It strikes N. 35° W. and dips 48° SW. near the surface, in granodiorite. The recently started shaft is 1500 ft. northwest of the present Longan shaft on the Zantgraf vein.

A mill of two 650-lb. stamps and a small concentrator has recently (April, 1937) been erected to mill ore taken out in sinking the shaft. This shaft was about 10 ft. deep at time of visit. Besides pyrite and free gold, a part of the vein near the footwall carries a silver-bearing sulphide containing a little copper and lead. Not enough of this has been taken out yet to give a conclusive test, but it resembles stromeyerite, not previously reported in this district.

Wulff Placer. On the W. C. Wulff ranch, in sec. 8, T. 10 N., R. 9 E., five miles northwest of Rescue.

A small placer deposit apparently formed by erosion from the nearby hillsides into a small basin, was being worked by two men at time of visit. About 2½ ft. of soil and clay overburden has to be removed from the 'pay dirt' which consists of broken rock debris 1 ft. to 1½ ft. thick on gabbrodiorite bedrock. Only a few cubic yards of material is hauled daily one-half mile to a small washing plant where a 1½-inch pump supplies 32 g.p.m. of water from a small creek for sluicing. A good profit was being realized.

Zantgraf (Montauk Cons.) Mine is eight miles southeast of Newcastle on the east side of American River near Rattlesnake bridge.

The mine was discovered in 1880 by Jacob Zantgraf, on land which had been patented years before by the Central Pacific Railroad Company, as agricultural land, because the veins do not outcrop conspicuously. About 1883 Zantgraf put up the first mill, of five stamps which was operated about seven months each year by water power, and worked the vein through two adits. In 1886 five stamps were added to the mill. The main vein was worked down to the 300 level adit, and was stoped for a length of about 900 ft. During the time it was worked by Zantgraf & Company the mine produced $438,000. In 1895, because of family disagreements, lack of money for sinking, and probably also because they thought the mine was nearly worked out, it was sold to Senator Chapman for $65,000. He renamed it the Montauk Consolidated, sank the shaft to the 800 level, put up a new 20-stamp mill and produced over $200,000 before January, 1898, when the mine was sold to *Montauk Consolidated Mining Company* for about $100,000. The property was then supplied with electric power from its own hydroelectric plant near by on American

River and 5 stamps were added to the mill. From May, 1898, to May, 1901, they produced over $351,000, the shaft meanwhile having been sunk to 1130 feet. The company became involved in lawsuits for damages and were hard pressed by creditors seeking pay for surface equipment and machinery, much of which should not have been bought. During a temporary shutdown in October, 1901, a fire burned the hoist, shops and mill and the mine has been idle since.

The Zantgraf, Montauk and other nearly parallel veins occupy fissures in granodiorite and amphibolite schist and are accompanied by diorite dikes. They strike northwest and dip southwest from 38° to 50°. Near the main shaft the Zantgraf and Montauk veins are 180 feet apart, diverging to the northwest. Most of the mine workings are in the granodiorite and all the production has been from the Zantgraf vein, only small test lots having been milled from the Montauk and Porterfield veins on this property. On the adjacent land some work has been done and some ore crushed on a vein which appears to be the Montauk. The main vein pinches and swells both vertically and horizontally and the value of ore varies widely, but there was usually from two to six feet of good ore with a gouge up to a foot wide. The ore averaged about $8 a ton, although considerable specimen ore occurred, and the bullion ranged in value from $11 to $14 an ounce. High-grade pyrite and galena formed 1% to 1½% of ore from the 600 level downward. The concentrate contained at times as high as $90 gold and 90 to 100 ounces silver per ton besides which considerable pay was lost in the slimes, as a slime plant added in 1898 gave slimes assaying 128 ounces silver and 1.3 ounces gold per ton.

The later operations were through an inclined shaft on the Zantgraf vein to a depth of 1130 ft. (715 ft. vertical). Two ore shoots were developed; above the 300 adit level they were stoped as one for a length of 900 ft. Below that level most of the ore came from the south ore-shoot, which pitched away from the shaft and was about 600 ft. long to the 10th level. Levels were run every 100 ft. to 1100 level, where the ore shoot was entered 309 ft. from the shaft and followed for over 300 ft. just previous to closing the mine. The assay values on this level varied from $2 to over $100 a ton but apparently averaged about $7 to $8 a ton. The vein has been explored for a maximum of 1600 ft. in length.

Since 1933, W. B. Longan has been prospecting the property and has sunk two shafts, with considerable drifting. On the Montauk vein a few hundred feet north of the old main shaft, he sank a shaft 190 ft. deep and drifted southeast 470 ft. and northwest 35 ft. Though the vein is of good width, it did not show in this distance any commercial orebody.

Later he sank a shaft on the Zantgraf vein 900 ft. northwest of the old shaft. This at present (April, 1938) is 200 ft. deep on the vein which dips 56° 50′ SW. to a depth of 125 ft. and flattens to 51° below there. Drifts were turned at 80 and 180 ft. deep. The upper level was run 140 ft. NW. and 95 ft. SE. and from the latter a crosscut was run to connect with the old 300-ft. adit level. On the 180-ft. level, drifts have so far been run 142 ft. SE. and 108 ft. NW. The vein in these drifts is reported to be from 1 ft. to 1½ ft. wide. The 180 ft. level is under water but some mining has been done

lately from the 80-ft. level and small lots of ore have been hauled to custom mills with encouraging returns. Longan claims that ore extends the entire length of this level so far as opened and that the northwest face is still in ore. He thinks this is a part of the original long ore shoot worked on the southeast above the 300-ft. level by J. Zantgraf, whose work did not extend this far north. If this is true, it would be one of the longest ore shoots in the state. The quartz and walls are ''picking ground'' so far, and the gold is free, but unoxidized ore with galena and pyrite is beginning to show in the 180-ft. level.

On April 14, 1937 a Beer mill (modified Chilian mill) with a capacity of 50 tons a day, was being installed. Four men were employed. This mill was later replaced by a ball mill which was being operated late in the spring of 1938.

TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
Adams Gulch & Sullivan	25, 26	9 N.	10 E.	Camilla D. Heald and Virginia McDouall, Nashville	41	XII, p. 101; XIII, p. 132; XV, p. 279; Bull. 108, p. 15
Adjuster	12	9 N.	10 E.	Mrs. Cecilia Simpson	21	XV, p. 280; Bull. 108, p. 15
Adjuster and Hustler	12	9 N.	10 E.	R. B. Seward, Diamond Springs	40	XV, p. 279
Alabama	12, 13	9 N.	10 E.	El Dorado Mining Company	5	
Albright	17	10 N.	11 E.	Placerville Gold Mng. Co.	70	See Pacific
Alhambra	6, 7	11 N.	11 E.	Pearl McKee, et al., Placerville	10	X, p. 178; XXXI, p. 22
Alpine	15, 16	12 N.	10 E.	Lucero Gold Mng. Co., Inc., 530 Wilcox Bldg., Los Angeles	180	VIII, pp. 167-68; XIII, p. 132; XV, p. 280; Bull. 108, pp. 15-17
	15, 22	12 N.	10 E.	Alpine Gold Mng. Co.	8	
American Seam						Bull. 108, p. 45
Arctic	20	9 N.	13 E.	Mary J. Irwin, et al.	27	
Argonaut	17	12 N.	10 E.	Gold Unit Mng. Co., c/o Ralph E. Fry, R.F.D. 2, Box 1736, Sacramento	25	VIII, p. 176; X, p. 176; XII, pp. 101-102; XIII, pp. 132, 133; XV, p. 280; XVIII, p. 209; Pre. Rep. 8, p. 29; Bull. 108, p. 17; XXII, pp. 413-414.
Armstrong & Roberts	38	9 N.	13 E.	Armstrong Mng. Co., 9th and Broadway, Oakland	30	XII, pp. 101-102; XV, p. 301; XVII, pp. 425-26
Atlanta	7	11 N.	11 E.	Atlanta Gold & Silver Mining Co., c/o Pearl McKee, Placerville	21	
Atlantic	17	10 N.	11 E.	Estate of John F. Limpinsel, Placerville, et al.		
Aultman						See Argonaut
Baldwin	1, 2	8 N.	10 E.	Estate of E. J. Baldwin, San Francisco	20	XII, p. 102; XIII, p. 133; XV, p. 280
Balmaceda	35	9 N.	10 E.	Estate of J. C. Heald, Nashville	20	XV, p. 280
Baltic	23	10 N.	13 E.	Reed & Sciarossi, Placerville	80	XIII, p. 133; XV, p. 280
Barbara	32	11 N.	10 E.	Sarah Veerkamp; Leland W. Veerkamp, Placerville	14	
Barnes-Eureka	28, 33	10 N.	10 E.	Edward H. Polk	40	XII, pp. 102, 112; XIII, p. 144; XV, p. 281
Barney	15, 22	12 N.	10 E.	Hattie C. Schneider	20	
Bathurst						See Coe Hill
Beattie and Parsons	3 34	12 N. 13 N.	10 E. 10 E.	Ida B. Ackley, Georgetown; Emma B. Shutz, Arbuckle; et al.	60	XI, p. 203; XII, p. 102; XIII, p. 133; XV, p. 281; (see Georgia Slide also).
Beebe				Pacific Mining Co., Crocker Bldg., San Francisco		Bull. 108, pp. 17-19; 207-211
Bell	36 6	11 N. 10 N.	10 E. 11 E.	Laura B. Clark and Guilford Gold Mining Co., Placerville	10	See River Hill
Bidstrup	11	9 N.	10 E.	Walter I. Bidstrup, El Dorado	8	XII, p. 103-104; XIII, p. 133; XV, p. 281
Big Buzzard or Hercules	29	11 N.	8 E.	George Darrington, Mabel Scott et al.	20	XVII, p. 430; XVIII, p. 209; XIX, pp. 141-42; XXII, p. 406, 412
Big Canyon (Oro Fino)	29	9 N.	10 E.	Mountain Copper Co., 112 Market St., San Francisco	59	VIII, pp. 174-75; XVIII, p. 209; XXII, p. 412; XV, p. 293; XXXI, p. 22; XIII, p. 133; XII, pp. 103-104
Big Chunk	24	11 N.	10 E.	Margaret E. Smith, et al., Placerville	13	XV, p. 281; Bull. 108, p. 19

Big Four	34	12 N.	10 E.	B. O. Curry, P. D. Burtt, James O'Brien, Kelsey	16	XV, p. 281; Bull. 108, p. 19
Big Kennebec	32, 33	13 N.	9 E.	Howard W. Davis	12	
Big Sandy	24	11 N.	10 E.	Big Sandy Mining Co., c/o James Kelley, Kelsey	109	X, p. 173; XII, p. 104; XIII, p. 134; XV, p. 281; Bull. 108, pp. 19-20
Bird	20	10 N.	11 E.	Arthur H. S. Bird	6	
Black Hawk	24	11 N.	10 E.	Oscar Reeg, Placerville and Estate of Blair, Placerville	20	XV, p. 281
Black Oak	34	12 N.	10 E.	R. J. Wilson, Garden Valley		Bull. 108, pp. 20-21
Blair	9	10 N.	12 E.	Ruth S. Soule and W. A. Richardson	40	X, p. 179; XII, p. 104
Blasdel						Bull. 108, p. 44
Blue Bank					20	XIII, p. 134; XV, p. 281
Blue Gouge	21	10 N.	13 E.			XIII, p. 135
Blue Ledger	6	11 N.	11 E.	William Hodge	21	
Blue Lead	3	11 N.	10 E.	Mrs. M. P. Bennett, Placerville		Bull. 108, p. 21; see also Isabell
Blue Rock	34	13 N.	10 E.	James E. Flynn, Georgetown, et al.	24	XI, p. 203; XII, p. 104; XV, p. 282; see Georgia Slide Mines also
Blue Point						XI, p. 203
Board						XII, p. 104; XIII, p. 135
Bobby Burns	4, 5	10 N.	12 E.	J. & J. Blair Land & Lumber Co., et al.	11	
Bona Forsa						X, p. 177
Bonanza	11	8 N.	10 E.	C. E. Padilla		XVIII, p. 44
Bon Sorte	6	10 N.	11 E.	Laura B. Clark, Placerville	14	
Boneset	3	10 N.	9 E.	M. & S. Dev. Co., 2811 G St., Sacramento, c/o Z. Smith, president		XII, p. 104; XIII, p. 135; XV, p. 282
Bordt	7	12 N.	10 E.	W. Bordt, Greenwood	20	XV, p. 282
Boston	18	11 N.	9 E.	Gue M. Allen	20	
Boulder	33	11 N.	9 E.	F. J. and G. R. Kaeser, A. Benedetti, et al.	20	XIII, pp. 135-136; XV, p. 282; XXXI, p. 22
Bower	7	12 N.	10 E.		20	XI, p. 204; XIII, p. 136; XV, p. 282
Briarcliffe Mines, Ltd.	2, 11 12	8 N. 8 N.	10 E. 10 E.	Supertest Bldg., London, Ontario, operators		See Baldwin Mine
Bright Hope	2	12 N.	10 E.	Maude A. Horn and Lucy L. Shine, 1525 20th Ave., Oakland		X, p. 177; XII, p. 105; XIII, p. 136; XV, p. 282
Brooklyn, Iowa and East Lode	2, 3	12 N.	10 E.		36	See Woodside-Eureka
Brown Bear	36	11 N.	10 E.			VIII, p. 182
Brust	6	11 N.	11 E.	Chas. N. & Frank P. Brust, Kelsey	37	XVIII, p. 44; XXII, p. 412
Buena Vista	13, 24	9 N.	10 E.	W. C. R. Hoover, El Dorado Lease and option: John J. Schuster, R.F.D. 7, Box 2901, Sacramento	20	Bull. 18, p. 91
Bullion	31	10 N.	11 E.			
Calaveras	4 mi.	E. Latrobe				XIII, p. 136
Caldonia	15	11 N.	10 E.	Wayne Huckaby, 457 El Camino Ave., Sacramento		
California Cons.	21, 16	9 N.	13 E.	Wm. Brown, Oleta	60	XI, p. 201; XII, p. 113; XIII, pp. 145, 159; XXII, pp. 412-13
California Jack	22	12 N.	10 E.	Mrs. E. M. Potts and A. L. Jeffrey, 527 Citizens National Bank Bldg., Los Angeles	40	XIII, p. 136; XV, p. 282
Carrol Seam						Bull. 108, p. 45
Castillo	33, 34	12 N.	9 E.	Fred Castillo	21	
Castile Seam						Bull. 108, p. 45

* To save space, frequently only one of several names is shown in this column.

TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
Cedarberg	1 36	12 N. 13 N.	9 E. 9 E.	New El Dorado Gold Mining Co., c/o Grace E. Jennings	21	XII, p. 106; XIII, p. 137; XV, p. 282; Bull. 108, p. 45; MMR West of Rocky Mtns., 1873, p. 47; XXII, p. 413
Chaparral	26	11 N.	10 E.	Philip Stingle, Boston & Margaret Kelly, Kelsey	20	XV, p. 283; Bull. 108, p. 21
Cherokee Flat	24, 25	13 N.	9 E.	Chas. B. Davis & John Federwitz, Greenwood	18	
Chester	18	10 N.	11 E.			VIII, pp. 182-183; X, p. 173; XII, p. 106
China Hill	16	9 N.	10 E.	J. E. Fox, et al.	21	XII, p. 106; XIII, p. 137; XV, p. 283
Choller, Manzanita Queen & King	30, 31	10 N.	11 E.		62	See Griffith Cons.
Christian	28, 29	9 N.	13 E.	Cole Brothers	56	
Church	12	9 N.	10 E.	Seymour Hill, El Dorado; El Dorado Mining Company	80	VIII, pp. 191-193; X, p. 171; XII, p. 106; XIII, pp. 137-138; XV, p. 283; XVIII, p. 209; Bull. 18, p. 92; Bull. 108, pp. 21-22; XXII, p. 413
Cincinnati	3	11 N.	10 E.	W. J. and J. T. Davey, Garden Valley, et al.		XII, p. 106; XIII, p. 138; Bull. 108, p. 22
Cinnamon Bear	36	11 N.	10 E.			XI, p. 201; XII, p. 106
Climax	13	9 N.	10 E.	W. G. Busick & C. L. Pinney, E. H. Althoff	19	
Climax & Independence	14	11 N.	10 E.	W. A. Bell, c/o W. F. I. Bell, Kelsey	34	
Clyde	28	11 N.	9 E.	V. C. Sheehan, et al.	10	
Coe Hill	33	12 N.	10 E.	Ed Bathurst, Folsom		Bull. 108, pp. 22-23; XXII, p. 417
Collins & Bacchi	28	12 N.	10 E.		126	XV, p. 283
Columbia	18	10 N.	11 E.	Placerville Gold Mng. Co., c/o L. Weatherwax		
Conner Seam						Bull. 108, p. 45
Cousin Jack	29	9 N.	13 E.		20	XII, p. 107; XIII, p. 138; XV, p. 283
Cranes Gulch	15	12 N.	10 E.	Chas. E. Jerrett, et al., Georgetown	80	Bull. 108, p. 45
Crown Point Cons.	31	10 N.	11 E.	Charles T. Richards, et al., Placerville	40	XII, p. 107; XIII, p. 138; XV, p. 283; XX, p. 8; Bull. 108, p. 23
Crusader	12	9 N.	10 E.	Seymour Hill, El Dorado	60	XV, p. 284
Crystal	32, 33	9 N.	13 E.	Arthur S. Morey, et al.	31	XII, p. 107; XIII, p. 138; XV, p. 284
Crystal	18	9 N.	10 E.	Crystal Gold Mng. Co., c/o Wm. E. Kleinsorge, Sacramento	12	X, p. 178; XII, pp. 107-108; XIII, p. 138; XV, p. 284
Crystal	18	12 N.	9 E.	E. Terry, C. Ashley and C. Schulz, Cool	20	XIII, p. 138; XV, p. 284
Daily & Bishop	27	9 N.	13 E.	Bishop, et al., Grizzly Flat	40	XII, p. 108; XIII, p. 138; XIV, p. 284
Dalmatia	13	11 N.	10 E.	W. A. Bell, c/o W. F. I. Bell, Kelsey	102	VIII, p. 177; X, p. 174; XI, pp. 201-202; XII, p. 108; XIII, p. 139; XV, p. 284; Bull. 108, p. 23
Darling	33	12 N.	11 E.	P. G. Gilpin, 45 Crocker Bldg., San Francisco	20	XI, p. 202; XII, p. 108; XIII, p. 139; XV, p. 284
Davenport	34	12 N.	10 E.		320	Bull. 108, p. 21
Davidson	22, 27	10 N.	10 E.	Jerome Strickland, El Dorado, et al.	19	XII, p. 108; XIII, p. 139; XV, pp. 284-285
Day & Taylor	9	9 N.	13 E.	Grizzly Flat Mng. & Milling Company	20	
Defiance						XII, p. 108
Doncaster & Cleveland	11	11 N.	10 E.	E. E., A. C. and Jos. R. Maynard	7	
Donozo						XII, p. 108; XIII, p. 139
Drury						See Cedarberg

Dunlap	11	12 N.	12 E.	Boutwell Dunlap Estate, San Francisco	160	
Dunn-Vandenburg	20	10 N.	11 E.	Thos. E. Dunn and W. W. Vandenburg	17	
Dyer	9, 16	9 N.	13 E.	Maggie Dyer, et al.	5	
Eagle	7	12 N.	10 E.	A. B. Craig and wife	20	
Eagle	9	9 N.	13 E.	L. J. Kendrick, 3012 Shattuck Ave., Berkeley	48	VIII, p. 178; XIII, p. 139; XV, p. 285
Eagle King	4, 9	9 N.	13 E.	Mary Witmer, Ernest L. McAfee, et al.	10	VIII, p. 178; XII, pp. 108-109; XIII, p. 139; XV, p. 285
East Mother Lode	31	10 N.	11 E.	E. E. Twitchell	16	
East Nashville	2	8 N.	10 E.	Joshua Hendy Iron Works, San Francisco	17	
Edner					160	XII, p. 109; XIII, pp. 139-140; XV, p. 285
El Dorado & McKinley	25, 26	13 N.	9 E.	Kesington Gold Mng. Co., c/o Cleveland Forbes, 809 Merchants Exchange Bldg., San Francisco	36	
Elf	33	11 N.	11 E.	Pioneer Hardware Store, Placerville	40	
Elliott						See Sir Raleigh Mine
Emma	21, 28	12 N.	10 E.	Chas. E. Hand, Placerville	19	X, p. 176; XIII, p. 140
Empress	12, 13	9 N.	10 E.	El Dorado Mining Company	20	
Epley & Mammoth	20	10 N.	11 E.	Placerville Gold Mng. Co., c/o L. Weatherwax, Placerville	26	VIII, pp. 186-87; X, p. 173; XIII, p. 109; See also Pacific
Equator		10 N.	11 E.			VIII, p. 190;, X. p. 172; XII, p. 109
Esperanza	28	12 N.	10 E.	Garden Valley Gold Mining Co., c/o Haswell Bros., St. Johns Chambers, Chester, England	43	X, p. 175; XII, p. 109; XIII, p. 140;, XV, p. 285; Bull. 108, pp. 23-24
Esperanza	7	12 N.	10 E.		20	
Estelle	6 36	10 N. 11 N.	11 E. 10 E.	Mary E. McLaren (trustee)	14	
Eureka	6 36	10 N. 11 N.	11 E. 10 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville	13	X, p. 178; XI, p. 203; XII, p. 109; XV, p.285
Eureka	4	9 N.	13 E.	H. S. Treat, c/o D. C. Treat, Mission Savings Bank, S. F.	10	
Eureka	2, 11	12 N.	10 E.		16	See Woodside Eureka
Fairweather and Fairweather No. Extension	12	12 N.	9 E.			See Spanish Group
Falls	1	9 N.	10 E.	Joseph Drechsler, Diamond Springs	16	XV, p. 285; Bull, 108, p. 24
Faraday	20	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville		VIII, p. 186; X, p. 173; XII, p. 110; See also Pacific
Fiane	36	9 N.	10 E.	Philip A. and Laura C. Fiane	77	
Fisk						See Joseph Skinner Mine
Fine Gold	19	9 N.	12 E.	Alex J. Gray	40	
Frances Adams	25	11 N.	10 E.	Frank A. Losh	17	
Fort Yuma	29, 32	9 N.	10 E.	Jacob Baughman	29	XII, p. 110; XIII, p. 140
French	13	12 N.	9 E.	California Water & Mining Co.	18	XI, p. 204; XII, p. 110; XIII, p. 141; XV, p. 286, Bull. 108, p. 45
French Hill	36	13 N.	9 E.	Mrs. A. J. Johnson, Santa Monica and Mrs. E. S. Hadley, Sacramento	160	XII, p. 110; XIII, p. 141; Bull. 108, p. 47; XV, p. 286
Frog Pond & Marigold Cons.	28	12 N.	10 E.	S. W. Collins and Mary Norris, Garden Valley	17	XV, p. 286
Gallagher	5	12 N.	10 E.	F. G. Johnson and Jesse P. Hinck	21	
Gamblin						XXXI, p. 23
Gardner Cons.	6	10 N.	11 E.	Wm. H. and Emma L. Myers, Placerville	27	XV, p. 286
Garfield & Excelsior	5, 6	12 N.	10 E.		40	XII, p. 111; XIII, p. 141; XV, p. 286
Garibaldi Cons.						XII, p. 111; XIII, p. 141

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TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
General Lee, Sunday, Bosquit & Golden Age	19	10 N.	10 E.	Red Raven Cons. Mng. Co., c/o F. C. Hunter	71	
Gentle Annie	6	10 N.	11 E.	Laura B. Clark, Placerville	20	X, p. 177; XII, p. 111; XIII, pp. 141-143; See River Hill also Bull. 108, p. 45
Georgia Slide	3 34	12 N. 13 N.	10 E. 10 E.	Ida Barklage Ackley, Georgetown; Emma B. Schutz, Arbuckle et al.	86	XV, pp. 281, 282, 292; XX, p. 8, Bull. 108, pp. 45, 49; USGS PP 157, pp. 48-49
German & Richards	14	9 N.	10 E.	Seymour Hill, El Dorado	34	XIII, p. 142; XV, p. 286; Bull, 18, p. 90
Gibralter and Alta	1 6	9 N. 9 N.	10 E. 11 E.	Starlight Mining Co., c/o W. P. Frick	38	
Gillespie	17	10 N.	10 E.	Chas. E. Pine and Thos. G. Patton, El Dorado		
Gold Bug	20	12 N.	12 E.	Estate of John I. Martin, Placerville	20	
Gold Dust	12, 13	9 N.	10 E.	El Dorado Mining Company	20	
Golden Gate	14, 23	9 N.	10 E.	Charles T. Richards, et al., Placerville	21	X, p. 171; XII, p. 117; XIII, p. 150; XV. p. 286
Golden Rod	12, 13	9 N.	10 E.	El Dorado Mining Company	20	
Golden State	29, 32	13 N.	10 E.	Victor Forni	18	XI, p. 204; XII, pp. 111-12; XIII, p. 143; XV, p. 287
Golden Trace						See Flagstaff
Gold Mountain	11	8 N.	10 E.	Mrs. B. E. Carter, 811 E St., Sacramento, and Mrs. L. S. Sa[illegible]in, Nashville	40	XV, p. 286; Bull. 108, p. 50
Gold Note	4, 9	8 N.	13 E.	Walter L. [illegible] and Helen Dean	95	
Gold Top	12	9 N.	10 E.	Chas. F. Loo[illegible]rrow	21	
Good Hope	24	8 N.	9 E.	George B. Rym[illegible]	19	
Gopher-Boulder	11, 14	11 N.	10 E.	W. A. Bell, c/o W. F. I. Bell, Kelsey	40	VIII, pp. 175-77; XIII, p. 143; XV, p. 287; Bull. 18, p. 98; Bull. 108, pp. 24-25
Grand Victory	33, 34	10 N.	11 E.	Grand Victory Gold Mng. Co., c/o Geo. M. Clark, Placerville	72	VIII, p. 194; X, p. 178; XII, p. 112; XIII, p. 143; XV, p. 287; XXXI, p. 23
Gray		10 N.	9 E.			XII, p. 119; XIII, p. 143
Green Valley	22	10 N.	9 E.	John Meder, Folsom, et al.	8	
Griffith Cons.	30, 31	10 N.	11 E.	Charles T. Richards et al., Placerville	41	VIII, p. 189; X, p. 172; XII, p. 112; XIII, p. 144; XV, p. 287; Bull. 18, p. 92; Bull. 108, pp. 50, 25-26
Grit Cons. & Spanish Dry Diggings	30	13 N.	10 E.	Fred Husler, J. M. Dawson, Roy Croxen, C. Wachter	24	XVII, p. 426; XVIII, p. 44; XX, p. 8; Pre. Rep. 8, p. 29; Bull. 108, pp. 44, 46; XXII, p. 414
Grizzly Bear	36	11 N.	10 E.			XI, p. 201
Gross Cons. & Van Hooker	6	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville	21	VIII, p. 181; X, p. 173; XIII, p. 161; XII, p. 113; See also Pacific, and Harmon Group
Grouse Gulch	16	9 N.	13 E.		20	VIII, p. 178; XII, p. 113; XIII, p. 144; XV, p. 288
Guadalupe	11	11 N.	10 E.	Pioneer Hardware Store, Bernard Mierson et al., Placerville	10	

Guilford	25, 36 6	11 N. 10 N.	10 E. 11 E.	Guilford Gold Mining Co., Placerville	447	XV, pp. 287-288; Bull. 108, pp. 36-37; USGS PP 157, p. 49; XXII, p. 414
Hall Cons.						See River Hill
Harmon Group	6 36	10 N. 11 N.	11 E. 10 E.	Placerville Gold Mining Co., Placerville		VIII, pp. 181-182; X, pp. 173, 178; XI, p. 203; XII, p. 109; 113; XIII, p. 161; XV, p. 285; Bull. 108, p. 26
Harrison	7	10 N.	11 E.	Max Mierson, Placerville	21	
Hart				J. A. Flink, Garden Valley		Bull. 108, p. 47
Havilah						See Nashville
Henrietta	20	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville	14	VIII, p. 186; X, p. 173; XII, p. 113
Hidden Treasure	8	8 N.	13 E.	J. C. Baughmann, Indian Diggings	28	
Hines-Gilbert	24	13 N.	9 E.	Hines-Gilbert Gold Mining Co., 313 Capital National Bank Building, Sacramento. Lessee: Gold Fields Amer. Dev. Co.	14	XVII, p. 427; XVIII, p. 209; XX, pp. 178-179; Bull. 108, pp. 27-28, 46; XXII, p. 414
Hodge & Lemon						Bull. 108, p. 47
Holly	7	10 N.	11 E.	Holly Quartz Mini[illegible] Company	16	
Homestead	26	13 N.	10 E.		40	
Hope	12	11 N.	10 E.			XII, p. 113
Humphrey						XIII, p. 145
Hustler	12	9 N.	10 E.	Mrs. Cecilla S[illegible]son	21	
I Bid	21	9 N.	13 E.	William Brow[illegible], Oleta	20	See Calif. Cons. also; XII, p. 113; XIII, p. 145
Ida	18	10 N.	11 E.			VIII, pp. 182-183
Ida & Edith	34, 35	12 N.	11 E.	R. W. Brooke, Placerville	40	
Idaho	14, 23	9 N.	10 E.	Sidney Pringle, c/o E. C. Pringle, 354 Russ Bldg., San Francisco	20	XV, p. 288
Ida Livingstone	12, 13	11 N.	10 E.	Ida Livingston Mining Co., c/o Kenneth McLeod	15	XV, p. 288; Bull. 108, p. 28
Independence	14	11 N.	10 E.	W. A. Bell, c/o W. F. I. Bell, Kelsey	18	See also Climax & Independence
Independence	10	9 N.	10 E.		20	XV, p. 288
Indian Hill	5	10 N.	11 E.	Warren Crocker, John J. Dimon and Mrs. Leo Hamilton	80	
Indicator, S. W. H. and Martha L.	4	12 N.	9 E.	Eugene E. Howland		
Inez	1	8 N.	10 W.	Estate of S. H. Maginess, Placerville	184	X, p. 171; XII, p. 114; XIII, p. 147; XV, pp. 282-283
Isabell Group	3	11 N.	10 E.	Mrs. M. P. Bennett, Placerville	40	XV, pp. 288-289; Bull. 108, p. 28
Ivanhoe	28	12 N.	10 E.	Warren T. Russell	10	X, pp. 175-176; XII, p. 114; XV, p. 289
Jennings	22	11 N.	10 E.	Dalmatia Mining Co., c/o W. F. I. Bell, Kelsey	20	
Jones	6	9 N.	11 E.	J. M. Brown, Mrs. Allie Lange, Bakersfield, et al.	20	XV, p. 287; XVIII, p. 45; XIX, p. 142
Josephine or Shield	5, 6 7, 8	13 N. 13 N.	11 E. 11 E.	J. A. Shields, Auburn		VIII, pp. 165-66; X, p. 178; XI, p. 206; XII, p. 114; XIII, p. 147; XV, p. 289; XVII, p. 427
Joseph Skinner	7	10 N.	11 E.	J. H. Skinner, Placerville	17	XIII, p. 140; XV, pp. 285-86; Bull. 108, pp. 28, 45
Josh Billings	21	12 N.	10 E.	A. Siesnop, Garden Valley, James Johns, Auburn, Charles E. Hand, Placerville	20	
Kelly	13	11 N.	10 E.	Miss Margaret Kelly, Kelsey		Bull. 108, p. 29
Kelsey	24, 25	11 N.	10 E.	Kelsey Mining Co., Ltd., 519 California St., San Francisco	42	XV, p. 289; Bull. 108, p. 29, 211
Lady						See Kelsey
Lady Blanche	36	9 N.	12 E.	J. E. Stratton, San Francisco	60	XIII, p. 147; XV, p. 289

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TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
Lady Emma	13	11 N.	10 E.	Mary A. Peters, et al.	7	XIII, pp. 147-148; XV, p. 289
La Moille	11	9 N.	10 E.	Walter I. Bidstrup, El Dorado	11	XII, p 115; XIII, p. 148
Larkin	29	10 N.	11 E.	James Nickless, Sr.	28	XIII, p. 148; XV, p. 289; Bull. 18, p. 93; Bull 108, p. 30
Last Chance	15	10 N.	11 E.	Estate of G. Varozza, Placerville	54	XIII, p. 148; XV, p. 289
Last Chance	8, 17	11 N.	10 E.	Martha D. Franz, et al., 2818 O St., Sacramento; B. R. Heikens, c/o Mrs. Marie Von Buelow, et al., Coloma		
Levitt Cons.	30	11 N.	10 E.	Arthur W. Richardson, c/o Eunice R. Levitt	40	
Lincoln	3	12 N.	10 E.	Mrs. Melvin Groves, 681 Eileen St., Oakland	20	XIII, pp. 148-149; XV, p. 289
Lincoln	34	13 N.	10 E.	P. F. and James L. Morgan, Georgetown		XXII, p. 414
Live Oak	3 33	10 N. 11 N.	11 E. 11 E.	Live Oak Mining Company		
Live Oak						XII, p. 116; XIII, p. 149
Log Cabin	30	9 N.	10 E.	N. H. Cook and E. T. Cook		XII, p. 116; XIII, p. 149; XV. p. 289
Lone Jack	28	12 N.	10 E.	Campbell & Metson, San Francisco	20	X, p. 176; XII, p. 116; XIII, p. 149; XV, p. 290
Lone Star	11	8 N.	10 E.	Camilla D. Heald and Virginia H. McDouall, Nashville	20	X, p. 178; XII, p. 116; XIII, p. 149; XV, p. 290
Lone Star	31	10 N.	11 E.	E. E. Twitchell	21	XII, p. 116; XIII, p. 149; XV, p. 290
Lookout	11	9 N.	10 E.	Seymour Hill, El Dorado, and Estate of Lillie E. Hill	20	XII, p. 116; XV, p. 290; XVIII, p. 45; Bull. 108, p. 30
Lookout & K. K.	19	13 N.	11 E.	Wilson Cary, Georgetown	53	XIII, p. 149; XV, p. 290
Loveless	11, 14	9 N.	10 E.	L. T. Loveless & Bros., El Dorado	14	XV, p. 290
Lucinda				D. Gallagher, et al., Grizzly Flat	18	XIII, p. 149; XV, p. 290
Lucky Jack	11	9 N.	10 E.	Thomas Murphy, Logtown	18	XV, p. 290
Lucky Marion	12	12 N.	9 E.	Lucky Marion Mng. Co., 619 St. Charles St., St. Louis	20	XIII, p. 150; XV, p. 290; Bull. 108, p. 30
Lucky Star	6	10 N.	11 E.	Laura Clark	15	See River Hill
Lukens	25	12 N.	8 E.	Estate of G. E. Lukens, J. E. Lukens, Auburn		XIX, pp. 142-43; XXII, pp. 414-415
Lyon	6	10 N.	11 E.	Laura B. Clark	12	See River Hill
Lyon	21	10 N.	11 E.	Arthur S. Lyon, et al.	12	
Madrona	29	12 N.	10 E.			XII, p. 117
Maltby	17	12 N.	10 E.	A. C. Bequette	20	
Mameluke	3	12 N.	10 E.	P. F. and James L. Morgan, Georgetown	130	XI, p. 203; XV, p. 290
Mammoth	3, 4	10 N.	9 E.	Annie G. Jurgens and Dorothy Kipp, Rescue	9	XIII, p. 150; XV, p. 290
Manhattan Cons.	36	9 N.	10 E.	Nellie A. White, et al., Box 695, Coalinga	77	XV, p. 291
Manzaneta	24	11 N.	10 E.	Mrs. G. C. Baum	17	Field Report
Margareth	25	9 N.	10 E.	Arthur Lambrecht and Fritz C. Schneiber	20	
Marguerite	20, 29	10 N.	11 E.	Fannie S. Larkin and Chas. W. Ball	19	XV, p. 291
Marigold						See Frog Pond & Marigold
James Marshall						See Big Sandy Mine
Martinez Mines	12, 13	9 N.	10 E.	Martinez Gold Mng. Co., El Dorado	96	XV, p. 288; Bull. 108, pp. 30-31; XXII, p. 415
Maryland	17, 18	10 N.	11 E.	Placerville Gold Mng. Co.		See Pacific
Mathenas Creek	31	10 N.	11 E.	Sophia Schainman	21	VIII, p. 190; X, p. 172; XII, p. 117; XIII, p. 150; XV, p. 291

Mauley Seam Mine						Bull. 108, p. 45
McCurdy	12	8 N.	10 E.	Edith P. McCurdy	20	
McDowell	36	9 N.	10 E.	Estate of W. B. Hammell, c/o Mrs. Ruth H. Graeber, Lillie E. Hill and Seymour Hill, El Dorado	12	
McNulty	14, 23	9 N.	10 E.	Charles T. Richards, et al.	21	See Golden Gate
Melton	4	9 N.	13 E.	Melton Gold Mines, Ltd., R. O. Camozzi, Mgr., Grizzly Flat	54	VIII, pp. 177, 180; XII, p. 117; XIII, p. 150; XV. p. 291
Middle Fork	1, 12	13 N.	10 E.	Middle Fork Qtz. Mining Co.		
Middle End				Sciaroni Brothers		XXII, p. 418
Miller	20	10 N.	11 E.	Mary E. Goyan, Placerville	20	VIII, p. 189; X, p. 172; XII, p. 122; XIII, p. 150; XV, p. 291; Bull. 18, p. 94; Bull 108, p. 31
Miller	30, 31	13 N.	10 E.	C. O. Miller, 2214 M St., Sacramento	19	
Minerva	12	9 N.	10 E.	El Dorado Mining Co.	9	
Minnehaha	11	9 N.	10 F.	Walter I. Bidstrup, El Dorado	8	
Montana	19	13 N.	11 E.	J. Helmers, Georgetown, et al.	20	XIII, p. 151; XV, p. 291
Montezuma	1	11 N.	10 E.	Mary Witmer		
Montezuma & Montezuma Ext.	35 2	9 N. 8 N.	10 E. 10 E.	Camilla D. Heald and Virginia McDouall, Nashville. Operators: Montezuma-Apex Mining Co.	27	XII, p. 118; XIII, p. 151; XV, p. 291; Bull. 18, p. 91; Bull. 108, pp. 31-34; 205-207; XXII, pp. 415-416
Morey	16	9 N.	13 E.	E. R. Morey, Grizzly Flat	40	VIII, p. 178; X, p. 178; XII, p. 118; XIII, p. 151; XV, p. 291; XXII, p. 415
Morning Star, et al.	2	12 N.	10 E.	Estate of E. F. Porter, Georgetown	58	XXII, p. 415
Mother Lode	17	9 N.	10 E.	Michael B. Ryan		
Mountain Boy, Mountain Girl, Mountain Slide & Eastern Star	33	12 N.	10 E.	Jessie L. Whittle, 1716 Webster St., Oakland	20	Bull. 108, p. 51
Mount Hope	34	10 N.	13 E.	Sierran Mng. Co., c/o Judge Wildman, Norwalk, Ohio	40	VIII, p. 178; XII, p. 114; XIII, p. 151; XV, p. 292
Mount Pleasant	16	9 N.	13 E.	W. S. Kirk, Placerville	259	VIII, p. 178; X, p. 178; XII, p. 118; XIII, p. 151; XV, p. 292; XVIII, pp. 301, 209; XXII, pp. 416-417
Mulvy Point	35	13 N.	10 E.	Emma B. Shutz, Ida Ackley, et al.	80	XV, p. 292; See also Georgia Slide
Murray	17	8 N.	13 E.	Henry J. Garibaldi	51	
Nashville	2	8 N.	10 E.	F. J. Behnemau. Lessee: Montezuma-Apex Mining Co.	60	XII, p. 119; XIII, p. 151; XV, pp. 292-293; XVIII, pp. 45, 209; Pre. Rep. 8, p. 30; Bull. 18, p. 91; Bull. 108, p. 27
Nashville So. Ext.	2	8 N.	10 E.	Gladys M. Shores	20	
New Eldorado	36	13 N.	9 E.	New Eldorado Mng. Co., c/o E. Jennings, Box 1547, R.F.D. 4, Napa		XII, p. 119; XIII, p. 152; XV, p. 293
New Era	6 36	10 N. 11 N.	11 E. 10 E.	Laura B. Clark	12	See River Hill
New Garibaldi	12	12 N.	9 E.	J. B. Hayes, San Francisco	20	XIII, p. 152; XV, p. 293
North St. Lawrence	2, 3	11 N.	10 E.	Pioneer Hardware Store, Placerville and Bernard Mierson, et al.		See St. Lawrence Mine
North Star	32	10 N.	10 E.	Senf Draying Company	20	
Ohio & Eagle	7	12 N.	10 E.		18	XII, p. 119; XIII, p. 152, 157; XV, p. 293
Oak	32	9 N.	13 E.	J. Ryan, Grizzly Flat	35	XII, p. 119; XIII, p. 152; XV, p. 293
Old Hickory	25	11 N.	10 E.	Kelsey Mining Company, 519 Calif. St., San Francisco	17	
Old Jasper					80	XIII, p. 152

* To save space, frequently only one of several names is shown in this column.

TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
Old Quartz	12	9 N.	10 E.	E. H. Pearce Estate, c/o Carrie C. Pearce	11	
Olive	7, 18	12 N.	10 E.	Sarah J. Dorn, 812 Phelan Bldg., San Francisco	20	
Omo	32	9 N.	13 E.	G. W. Mock, Ono Ranch	60	XIII, pp. 152-153; XV, p. 293
One to Sixteen and Vulture Mines	6, 7	10 N.	11 E.	W. A. Craddock, Placerville	25	XV, p. 293
Ophir	11	9 N.	10 E.	Walter I. Bidstrup, El Dorado	14	Bull. 108, pp. 34-35
Oregon	18	10 N.	11 E.	Pardi Litizia, Placerville		VIII, pp. 182-183; X, p. 173; XII, p. 119; XIII, p. 153
Oregon Hill						See Pacific
Oro Flam (Oriflamme)	31	10 N.	11 E.	Mill B. Maginess et ux, 1607 9th Ave., San Francisco	20	VIII, pp. 189-190; X, p. 172; XV, p. 293
Oro Fino	33	12 N.	10 E.	Sam W. Collins, Garden Valley	40	Bull. 108, p. 35; XXII, p. 417
Orum	12	9 N.	10 E.	Orum Mining & Development Co., O. A. Ingraham, Placerville	45	XV, p. 300; Bull. 108, p. 35
Pacific	34	13 N.	10 E.	Emma B. Shutz, Ida B. Ackley, et al.	6	XV, p. 292; See Georgia Slide also
Pacific	17, 18	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville	13	VIII, pp. 183-186; X, p. 173; XII, p. 120; XIII, p. 163; XV, pp. 293-295; XVIII, p. 209; Bull. 108, pp. 35-36; XXII, pp. 417-418
Padre						XII, p. 120; XIII, p. 153
Paulson	29	9 N.	13 E.	P. A. Paulson	34	
Peterson	24, 25	11 N.	10 E.	Kelsey Mining Co., Ltd., San Francisco	18	
Philadelphia and Gold Note	21, 22	8 N.	13 E.	J. B. Polk and Parker Brothers, Omo Ranch	70	XII, pp. 120-21; XIII, p. 153; XV, p. 295
Philip Joiner & Black Hawk	3, 4	9 N.	13 E.	Agostino Sciaroni, Jr., et al.	20	
Pocahontas	10, 11 14, 15	9 N. 9 N.	10 E. 10 E.	Geo. Q. Bell and Helen C. Chase; Seymour Hill, El Dorado	37	XII, p. 121; XIII, p. 154; XV, p. 295; Bull. 18, p. 95; Bull. 108, p. 36
Polar Bear, White Bear, Empire Gr.	29, 32	9 N.	13 E.	J. T. and J. Q. Wrenn, Placerville	404	XV, p. 295
Potossi	30	10 N.	11 E.	Chas. T. Richards, et al.	40	
Poverty Point						See Guilford
Pyramid	12, 13	10 N.	9 E.	F. J. Kaeser, Rhoads Grimshaw, et al.	24	XII, p. 121; XIII, p. 154; XV, p. 295; XXXI, p. 23
Quiggle	12	11 N.	10 E.	John Quiggle	30	
Rainbow	21	12 N.	10 E.	J. Ramsdell and C. M. Root, Garden Valley	20	XIII, p. 155; XV, p. 295
Rattler	20	10 N.	11 E.			XII, p. 122; XIII, p. 155
Red Hill	11	11 N.	10 E.	E. E., A. C. and Jos. R. Maynard	21	
Red Rover		10 N.	9 E.			XII, p. 122; XIII, p. 155; XVII, pp. 427-28
Red Top	12, 13	9 N.	10 E.	Martinez Gold Mines Co., El Dorado	6	
Red Wing	14, 23	9 N.	10 E.	W. H. Jones, J. E. Sawyer, P. J. Loveless, El Dorado	20	XV, p. 296; XVIII, p. 301
Reed and Keyser	7	10 N.	11 E.	Mary Limpinsel, Placerville		
Revenge		13 N.	9 E.			XII, p. 122
Richilieu	1, 12	9 N.	10 E.	Richilieu Mining Company	20	
Richmond & Syracuse	4 33	8 N. 9 N.	13 E. 13 E.	Mary Witmer, et al., Placerville	38	XV, p. 296
Ringgold Lode & Keystone	20, 29	10 N.	11 E.	Fannie S. Larkin	36	

Rising Sun	14	11 N.	10 E.	Nettie L. Forni and Josephine Simpers, San Francisco	15	XV, p. 296
River Hill	6	10 N.	11 E.	Laura B. Clark, Placerville & Guilford Gold Mining Co., Placerville	178	X, p. 177; XII, p. 111; XIII, pp. 141-143; XV, p. 296; Bull. 18, p. 94; Bull. 108, p. 37
Rose	18	10 N.	11 E.	Placerville Gold Mining Co., Placerville		VIII, pp. 182-183; XII, p. 122; XIII, p. 155
Rose	6	11 N.	9 E.	Henry H. Rose, Auburn	14	
Rosecranz	21	12 N.	10 E.	Geo. Steppe, Placerville; Chas. R. Young, Bijou, Lillie M., Eva, Wm. Cook, c/o Arthur S. Morey, 630 11th Ave., San Francisco; Mrs. Sallie Mitchell, Placerville; A. Siesnop, Garden Valley; Josephine F. Simpers, 1559 Sacramento St., San Francisco	20	VIII, p. 171; X, p. 176; XIII, p. 155; XV, p. 296
Rose Kimberly No. 1, Rose Kimberly No. 2	10, 11	10 N.	9 E.	Estate of Fredman	150	
Rubicon & Alhambra	15	13 N.	11 E.	Ida Barklage Ackley, Georgetown; Emma B. Shutz, Arbuckle; Flora Barklage Laine, Hotel Sacramento, Sacramento	35	X, p. 178; XIII, p. 156
Ruxford	7	12 N.	10 E.	E. H. Ruxford, Title Ins. Bldg., 275 Bush St., San Francisco	20	
Ryan	24	11 N.	10 E.	M. B. Ryan, Placerville and Barrett Bros., Shingle Springs	20	XV, p. 296
Salisbury						XIII, p. 156
Sam Martin	6, 7	12 N.	10 E.	Ella S. Graves, c/o W. L. Thompson, East Liverpool, Ohio		XII, p. 122; XIII, p. 156
Santa Claus	7	12 N.	10 E.	B. Rainy, Greenwood, et al.	20	
Schneider						See Mathenas Creek
School Girl & Union	12	9 N.	10 E.	El Dorado Mining Company	37	
Sebastopol	30, 31	13 N.	10 E.	Charles O. Miller, 625 36th St., Sacramento	19	
Selby	29	10 N.	11 E.	Warren Larkin, Placerville	60	XV, p. 296; Bull. 18, p. 93
Shan Tsz	21	10 N.	10 E.		20	VIII, p. 193; X, p. 181; XII, p. 481; XV, pp. 296-297
Sharp						VIII, p. 194; XII, p. 123; XIII, p. 156
Sherman	8	10 N.	11 E.	Sherman Mine & Milling Co., Placerville	80	XV, pp. 297-298
Sir Raleigh	31	10 N.	11 E.			XII, p. 109; XIII, p. 140
Sleeping Beauty	12	8 N.	10 E.	Mary C. Ruiz, et al.	10	
S. L. Hunt	30	12 N.	9 E.	Henry G. Meyer	11	
Sliger	36	13 N.	9 E.	Sliger Gold Mining Co., c/o W. H. Simpers, 3628 Fulton St., San Francisco	47	XII, p. 123; XIII, p. 157; XV, p. 297; XIX, p. 143; Bull. 108, pp. 38-40; XXII, p. 418
Smith						Bull. 108, p. 45
Snow Flake	12	12 N.	9 E.	Mrs. Lovenia E. Pease, Sacramento	13	See Spanish Group
Spanish Group	12, 13	12 N.	9 E.	Mrs. Lovenia E. Pease, 1621 16th St., Sacramento		Bull. 108, p. 47
Standard						XII, p. 123; XIII, p. 157
Starlight	10	9 N.	10 E.	Starlight Mining Company, c/o W. P. Frick	20	XII, p. 123; XIII, p. 157; XV, p. 298
St. Clair	14	11 N.	10 E.	Mary E. Peters, et vire, Kelsey	20	XV, p. 298
St. Lawrence	2, 11	11 N.	10 E.	St. Lawrence Gold Mining Co.	10	XI, p. 202; XIII, p. 156; XV, p. 298; Bull. 108, pp. 40-41. 47
St. Louis	13, 14 23, 24	9 N. 9 N.	10 E. 10 E.	Charles T. Richards, et al.	19	

* To save space, frequently only one of several names is shown in this column.

TABLE OF QUARTZ MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
St. John	34	13 N.	11 E.	Hattie M. Wilson, 858 S. Philadelphia St., Anaheim, John Boggs, 130 N. Calif. St., Stockton, et al.	30	
Stillwagon Group	32,33	9 N.	13 E.	Mary K. Pond and A. A. Helmke and wife		X, p. 178; XII, pp. 123-124; XV, p. 298
Strucklager	24	11 N.	9 E.	Beryl and E. J. McKenney, et al.	50	VI, p. 43: X, p. 178; XII, p. 124; XIII, p. 158; XV, p. 298
Sugar Loaf	1, 12	8 N.	9 E.	Justus C. Smith and Guy Atkinson	9	XII, p. 124; XIII, p. 158; MMR. West of Rocky Mountains, 1868, p. 88
Sunday	4, 9	9 N.	13 E.		20	XII, p. 124; XIII, p. 158; XV, p. 298
Sun Rise	24	11 N.	10 E.	Mary E. Barrette, Shingle Springs, and John F. Meder	10	XIII, pp. 158-159; XV, p. 299
Sunrise & Shadyside	19	12 N.	10 E.	W. H. Tuhrman, Travelers Hotel, Sacramento	40	
Superior	20, 29	10 N.	11 E.	Emma Rose, c/o Garrett W. McEnerny, 2002 Hobart Bldg., San Francisco	27	VIII, pp. 187-189; X, p. 172; XII, p. 124; XIII, p. 159; XV, p. 299; Bull. 18, p. 94; Bull. 108, p. 41
	30	10 N.	11 E.			
Superior No. Ext.	20	10 N.	11 E.	Annie J. Darlington	21	
Swansae & Rocky Bend	10, 15	11 N.	10 E.	W. E. and H. E. Kleinsorge, Sacramento		
Swift & Bennett	11	12 N.	10 E.			Bull. 108, p. 47
Sylvester	32	11 N.	10 E.	Albert C. Wellington and wife	20	
Taylor	21, 30	12 N.	10 E.	Walter L. and Helen Dean, San Francisco	17	VIII, pp. 168-171; X, p. 176; XI, p. 205; XII, p. 113; XIII, p. 145; XV, p. 299; XVIII, pp. 209, 210; Bull. 108, pp. 41-42
Threlkel	16	11 N.	8 E.	L. L. and Margaret Threlkel, Newcastle	120	XXII, p. 418
Tong	7	9 N.	9 E.	Fred H. Jenssen	10	
	12	9 N.	8 E.			
Treat	4	9 N.	13 E.		40	VIII, p. 178; XIII, p. 159; XV, p. 299
Treat Extension	4	9 N.	13 E.	Agostino Sciaroni, Jr., et al.	10	
Trench						See Yellow Jacket
True Cons.	6, 7	10 N.	11 E.	Placerville Gold Mining Co., Placerville		VIII, pp. 180-181; XII, p. 125; XIII, p. 144; See also Pacific
Tullis	1	9 N.	10 E.	Seymour Hill, El Dorado	16	XIII, pp. 159-160; XV, p. 299
Uncle Sam	2	12 N.	10 E.	W. R. Beattie and C. R. Benjamin, et al.	19	XIII, p. 160
	35	13 N.	10 E.			
Union	12	9 N.	10 E.	El Dorado Mining Company, c/o Chas. Hussey, 507 Empire State Bldg., Spokane, Wash.	61	VI, p. 43; VIII, p. 167; XV, p. 299; XVIII, pp. 209, 210; Bull. 18, p. 92; XXII, pp. 418-419; XXVIII, pp. 215-216; Bull. 108, pp. 42-43
Utah Apex						See Montezuma
Valdora				F. H. McAfee, Grizzly Flat		VIII, p. 178; XIII, p. 161
Van	2	12 N.	10 E.	W. L. Dickerson, San Francisco	20	XI, p. 203; XII, p. 126; XIII, p. 161; XV, p. 300
Vandalia	19	9 N.	10 E.	Vandalia Mining Co., c/o C. N. Busby		VIII, pp. 172-173, X, p. 178; XII, p. 126; Bull. 18, pp. 96-98; XVIII, p. 301; XXII, p. 419

Vandergreft	26	9 N.	10 E.		40	XV, p. 300
Van Hooker	6 36	10 N. 11 N.	11 E. 10 E.	Placerville Gold Mining Co., Placerville		VIII, p. 181; X, p. 173; XIII, p. 161; See also Pacific
Veerkamp	33	12 N.	10 E.			Bull. 108, pp. 37-38
Victoria				Grimshaw, Ferris & Cornelius, Rescue		XX, p. 178; XXII, p. 419
Wagner	11	8 N.	10 E.	Geo. E. and John Waggoner and F. B. McKevitt, et al.	92	XXII, p. 419
War Eagle	24	11 N.	10 E.			Bull. 108, p. 43
Waun	24	13 N.	9 E.			Bull. 108, p. 47
Webster	31	13 N.	11 E.	D. C. Webster, Georgetown	24	XII, p. 126; XIII, p. 161; XV, p. 300
Welch	7	12 N.	10 E.	J. A. Sisler, Visalia and Bryant Moore, Exeter	21	XII, p. 126; XIII, p. 161; XV, p. 300
Weske	3	12 N.	10 E.	Adolph Weske, c/o L. L. Clark, 501 S. Seville Ave., Huntington Beach	38	
White Bear	36	11 N.	10 E.	Part of Pacific		VIII, p. 182; XIII, p. 161
Wiedebush	20	13 N.	11 E.	A. E. Wiedbush		XVII, p. 428; XXII, p. 419
Wild Cat	20, 21 28, 29	12 N. 12 N.	10 E. 10 E.	Adelia A. Angier	20	
Wild Rose Cons.	13	9 N.	10 E.	Estate of F. H. Maginess, Placerville, c/o M. B. Maginess, 1607 9th Ave., San Francisco	67	Field Report
Wilhelm & Last Chance	25	12 N.	8 E.	Estate of G. E. Lukens, Auburn	40	XV, p. 300
Willimantic						XII, p. 126
Wiltshire	36	9 N.	10 E.	Elizabeth M. Green, 1723 K St., Sacramento and Joseph H. Woolford, Plymouth	11	XXII, p. 419
Woodside-Eureka	2, 3 11	12 N. 12 N.	10 E. 10 E.	Woodside-Eureka Mng. Co., c/o R. B. Myers, 204 Bacon Block, Oakland	115	XI, p. 200; XII, p. 126; XIII, p. 161; XV, p. 300
Yellow Jacket	18	13 N.	11 E.	Ruby F. Bryan, et al.	22	XII, p. 125; XIII, p. 159; XIV, p. 299
Young Harmon	7	10 N.	11 E.		28	See Pacific
Zentgraf & Homestead	16	11 N.	8 E.	H. B. Drescher and Louise Kleinsorge, Sacramento	9	VIII, pp. 200-202; X, p. 178; XIII, pp. 161-162; XV, p. 300; XVIII, pp. 209, 210; XX, p. 8;; XXII, pp. 419-420

* To save space, frequently only one of several names is shown in this column.

TABLE OF PLACER MINES AND PROSPECTS, EL DORADO COUNTY

Name of mine	Location: Sec.	Location: Twp.	Location: Range	To whom assessed*	Area, acres	Bibliography
Alveoro	3, 10	10 N.	11 E.	Estate of S. H. Maginess, Placerville	184	XV, pp. 300-301
American Bar, Winifred Shirley & Willow Bar	4	13 N.	11 E.	American Bar Qtz. Mining Co., 859 Mills Bldg., San Francisco	25	
	33	14 N.	11 E.			
Badger Hill	28	11 N.	12 E.		40	XV, p. 301
Bell	8, 17	8 N.	13 E.	Henry J. Garibaldi	155	
	18	8 N.	13 E.			
Benfelt	10	10 N.	11 E.		160	VIII, pp. 197-198; X, p. 179; XIII, p. 133; XV, p. 301
Bitters						See Two Channel
Blacklock	8, 17	10 N.	11 E.	Estate of S. H. Maginess, Placerville	25	XIII, p. 134; XV, p. 301
Black Rock	33, 34	12 N.	9 E.		26	XI, p. 203; XIII, p. 134
Brown's Bar	5	12 N.	9 E.	Howard W. Davis	34	
	32	13 N.	9 E.			
Brown & Thompson	34	13 N.	10 E.	George Brown and J. Thompson	4	
Buckeye	21	10 N.	11 E.	Mamie G. and G. W. Hinckley	24	Field Report
Buckeye Hill	7, 8	12 N.	10 E.	Henry A. Arvidson; Ellen Soderjelm and Oscar Jacobson	32	XII, p. 105; XIII, p. 136; XV, p. 301
	17, 18	13 N.	10 E.			
Buckeye Hill No. Extension		13 N.	10 E.	Henry A. Arvidson and Oscar Jacobson	20	
Burt Alley						XII, p. 105; XIII, p. 136
California Mohawk						See Fairplay
California & Virginia	32	14 N.	11 E.	Melvin T. Duffy and Walter W. Stevens	4	
Carrie Hale						XII, pp. 105-106; XIII, p. 136
Channel Bend	5, 7	13 N.	11 E.		40	XII, pp. 116-117; XIII, p. 137; XV, p. 301
Chili Ravine						XII, p. 106; X, p. 180; VIII, pp. 194-196
Clark	30	8 N.	10 E.	Mrs. L. M. Clark, Paul H. Clark, et al.	160	
Confederate	8	8 N.	12 E.		40	XIII, p. 138; XV, p. 301
Confidence Mng. Co.						XXXI, p. 23
Connor	33	10 N.	10 E.	F. M. McComas, R.F.D. L, Placerville		
Cooley	17	13 N.	11 E.	Wm. Ogle, Volcanoville	160	
Cow Bell	18	12 N.	12 E.	E. D. Butts		
Cox	16	10 N.	11 E.	John I. Martin, c/o Elsie Martin, Placerville	26	Field Report
DeLaney	2	8 N.	10 E.	Joe De Laney and Tom Kloezko	8	
Dividend	3	10 N.	9 E.		31	XII, p. 108; XIII, p. 139; XV, p. 301
Dorsey	17	8 N.	13 E.	Henry J. Garibaldi & Mary Weston	217	
Eagle	31	9 N.	13 E.	Frank E. Abbey and Edward J. King	112	
Edenborough	18	13 N.	11 E.	Elmer C. Ogle, Volcanoville	144	
Edner	8	8 N.	13 E.	J. C. Baughman, et al.		
Excelsior	18	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville		
Fairplay	34	9 N.	12 E.	Calif. Mohawk Mining Co.	60	XV, p. 301
Fine Gold	19	9 N.	12 E.	Alex J. Gray	40	
Franklin	6	10 N.	11 E.	Placerville Gold Mining Co., c/o L. Weatherwax, Placerville	80	XIII, pp. 140-141; XV, p. 301

Gignac	16	10 N.	11 E.	Olivene A. Stone	36	X, p. 180; XV, p. 301
Giltedge	9	8 N.	12 E.		160	XIII, p. 142; XV, p. 302
Gold Bug	32, 33 34	13 N. 13 N.	10 E. 10 E.		101	XII, p. 105; XIII, pp. 142-143; XV, p. 301; XVIII, p. 301; XXII, pp. 438-439
Gray Eagle	8	12 N.	11 E.		100	XII, p. 112; XIII, p. 143; XIV, p. 302
Grizzly Flat	15	9 N.	13 E.	William Voss, Grizzly Flat, et al.	90	XII, pp. 112-113; XIII, p. 144; XV, p. 302; XXII, p. 439
Harnish					40	XIII, p. 144
Hayward	18	8 N.	13 E.	Hayward, Hobart & Lane Estates, 1128 Merchants Exchange Bldg., San Francisco	358	XIII, pp. 145, 147; XV, p. 302
Hewitt Extension	25	9 N.	12 E.	Thomas A. Murray Estate, et al.		
High Tunnel						XXII, p. 439
Hines Slope	24	13 N.	9 E.	F. I. Green, et al.	150	
Hook & Ladder	10, 11	10 N.	11 E.	Toll House Mine, c/o S. Chamberlain, Mills Bldg., San Francisco	66	XVII, p. 428; XVIII, p. 45; XXII, p. 439
Horseshoe Bar & Boston Bar	32 4, 5	14 N. 13 N.	11 E. 11 E.	American Bar Quartz Mining Company, 859 Mills Bldg., San Francisco	56	
Horseshoe Flat	15	10 N.	12 E	Estate of S H Maginess, Placerville, c/o M. B. Maginess, 1607 9th Ave., San Francisco	400	XV, p. 302
Horswill	9, 10	4 N.	11 E.		160	XIII, pp. 108-109; Field Report
Hutchinson & Woodburn				Andrew Hutchinson & Charles Woodburn		XXII, p. 439
Jinkerson & Arditto				W. A. Jinkerson & J. Arditto		XXII, p. 439
Jones Hill Diggings	29	13 N.	10 E.		120	XI, p. 204
Jupiter	19	9 N.	12 E.	Ernest A. Gray, Mabel E. Gray	40	
Kentucky Flat	22	13 N.	11 E.	Andrew Chase & Wm. H. White, c/o Wm. S. Eaton, Rm. 87, 27 State St., Boston	403	XII, p. 115; XIII, p. 147; See also Norris & Kentucky Flat
Kum Fa	9, 10 15, 16	10 N. 10 N.	11 E. 11 E.	Oscar O. Reeg, et al., Placerville	140	XV, p. 302
Lady Bug	22	10 N.	10 E.	E. M. Fields	11	
Landecker Group	21	10 N.	11 E.	Hope Mining Co., c/o E. A. Gabriel, 917 H St., Modesto	400	Field Report
Lava Capped	1	8 N.	12 E.	Earl W., Bulah and Mary F. Frey	80	
Linden	16, 17	10 N.	11 E.		150	VIII, pp. 196-197; XII, pp. 115-116; XIII, p. 148; X, p. 179; XV, p. 302
Little Big Hole	30	9 N.	13 E.	George H. Wood, Placerville	20	XXII, p. 440
Little Chief	26, 35	13 N.	10 E.	W. R. Beattie and C. E. Benjamin, et al.	65	XII, p. 116
Little Flower	18	8 N.	13 E.	Edith M. Canvin, T. M. Canvin, S. C. Harrell, et al.	108	
Middle End						XXII, p. 418
Mississippi						See Norris
Mount Gregory	9	13 N.	11 E.		160	XIII, p. 151; XV, p. 302
Mooney	15	10 N.	12 E.		40	XII, p. 118; XIII, p. 151; XV p. 302
Murzo						XII, p. 119; XIII, p. 151
Nashville	2	8 N.	10 E.	Daisy Hayward	14	
Norris & Kentucky Flat	9 22	13 N. 13 N.	11 E. 11 E.	William S. Eaton, Rm. 87, 27 State St., Boston	893	XII, pp. 114-115; 117-119; XIII, p. 147, 150
Nutmeg	25	9 N.	12 E.	Wm. H. Stinson	20	
Old Empire	29	9 N.	13 E.	Alex Oliver, c/o Dorthy M. Oliver	34	
Pacific	34	13 N.	10 E.	Emma B. Shutz, Arbuckle; Ida B. Ackley, Georgetown, et al.	6	XV, p. 292; See also Georgia Slide Mines

* To save space, frequently only one of several names is shown in this column.

TABLE OF PLACER MINES AND PROSPECTS, EL DORADO COUNTY—Continued

Name of mine	Location			To whom assessed*	Area, acres	Bibliography
	Sec.	Twp.	Range			
Pacific Channel	34	11 N.	13 E.	John E. Sexton, Palisade, Nevada. Local agent: T. G. Patton, Placerville	------	Pre. Rep. 8, p. 30; XVII, pp. 428-429; XXII, p. 440
Payne	28	9 N.	13 E.	Cole Brothers, Pleasant Valley	40	XII, p. 120; XIII, p. 153; XV, p. 302
Pebble Hill	13	10 N.	11 E.	Nicola Fossati, Smith's Flat & Placerville Gold Mng. Co., Placerville	57	
Pioneer	6	10 N.	12 E.	Charles Schaeppi	31	
Plattsburg	------	------	------	------	22	XIII, p. 154
Potts & Maginess	21	10 N.	12 E.	Estate of S. H. Maginess, Mrs. W. E. Beck, et al., Placerville	100	XV, p. 302
Quail	9	8 N.	13 E.	John R. Labor	40	
Rau & Patterson	34	13 N.	10 E.	M. F., D. M., J. D. and P. C. Flynn; Mrs. Kate Smith; Geo. C. Rau c/o J. Wesley Rau, et al.	60	
Rising Hope	15	10 N.	11 E.	Schuyler N. Warren, 51 Exchange Place, New York	228	XV, p. 303; XVII, p. 429; XXII, p. 440
Rivera	16	10 N.	11 E.	J. Q. Wrenn Estate, c/o L. J. Anderson, Placerville	63	XV, p. 303
Rocky Bar	25	9 N.	12 E.	Thomas A. Murray Estate, et al., Cole Station	------	XXII, p. 440
Rocky Point	6	12 N.	9 E.	Howard W. Davis	43	
Roundout	------	------	------	Richards and Fairchild	------	XVII, pp. 429-430; XXII, p. 438
Sailor Slide	3 34	12 N. 13 N.	10 E. 10 E.	Charles F. Hickman, Swift Bldg., Columbus, Ohio	35	
Santa Rosa	------	18 N.	11 E.	------	300	XII, p. 122; XIII, p. 156
Slug Gulch	26	9 N.	12 E.	John L. Schenck and John R. McKee		
Stewart	20	10 N.	11 E.	Stanley F. Triplett	92	X, p. 180; XII, p. 123; XIII, p. 157; XV, p. 303
Table Rock	30	11 N.	11 E.	Mary Witmer	11	
Texas Hill	------	------	------	------	------	XII, pp. 124-125; XIII, p. 159
Toll House	10	10 N.	11 E.	Toll House Mine, c/o S. Chamerlain, 846 Mills Bldg., San Francisco	134	X, p. 179; XIII, p. 159; XV, p. 303; See also Hook & Ladder
Try Again	15	10 N.	11 E.	------	40	XIII, p. 159; XV, p. 303
Two Channel	15, 22 34 8, 9 10	13 N. 13 N. 13 N. 13 N.	11 E. 11 E. 11 E. 11 E.	Century Mining Co., 43 N. First St., San Jose	1955	XIII, p. 160
Union	3 33	10 N. 11 N.	11 E. 11 E.	------	78	XV, p. 303
Union Wisconsin River	20	10 N.	8 E.	Nellie Miller and Agnes Gray, c/o V. Gray		
Unity	3, 4	10 N.	11 E.	------	178	XII, pp. 125-126; XIII, p. 161
Uno	------	8 N.	12 E.	------	40	XIII, p. 161
Volcanoville	5, 8	8 N.	13 E.	Leslie C. Baughman, et al.	67	
Wabash Deep Channel	26	13 N.	10 E.	E. W. Claresse, Georgetown	160	XVII, p. 430
W. W.	------	------	------	------	------	XII, pp. 126-127; XIII, p. 161
Zimmerman	------	------	------	------	------	See Pacific Channel Mine

* To save space, frequently only one of several names is shown in this column.

LIMESTONE AND LIME

Next to gold, the most important mineral product of the county is limestone. The deposits are mostly in the form of upright lenses and have been classified as part of the Calaveras (Carboniferous) formation. They are usually enclosed in amphibolite schist which shows schistosity striking northwest to north, and dipping 70° to 85° northeast. The bodies of limestone conform in greatest length and depth with these directions. The largest outcrops extend north from near Cool into Placer County. Other deposits already opened are found at intervals going southward. Development has been confined to those lying within reasonable distance of the main-line of the Southern Pacific (Ogden Route) or its Placerville branch. Farther east are found other deposits, notably the marble at Indian Diggings, which remain undeveloped because of their distance from the railroad.

Four companies mentioned hereunder produced 159,134 tons of 'industrial' limestone in 1936, which was over $\frac{1}{2}$ of all that produced in the state; besides which, two of the plants burned considerable lime.

Auburn Chemical Lime Co. Since 1930 this company has been operating the quarry, crushing plant and lime-kilns formerly worked by *Newcastle Lime Company* and *Farmer Lime Company,* and many years ago by *Holmes Lime Company.* T. L. Chamberlain, Auburn, is president of the company.

The property is in the NW$\frac{1}{4}$ sec. 15, T. 11 N., R. 8 E., 7 miles by road southeast of Newcastle. The limestone deposit was in the form of a large, upright lens of good grade, colored gray. It is

Plant of Auburn Chemical Lime Co., near Rattlesnake Bar.

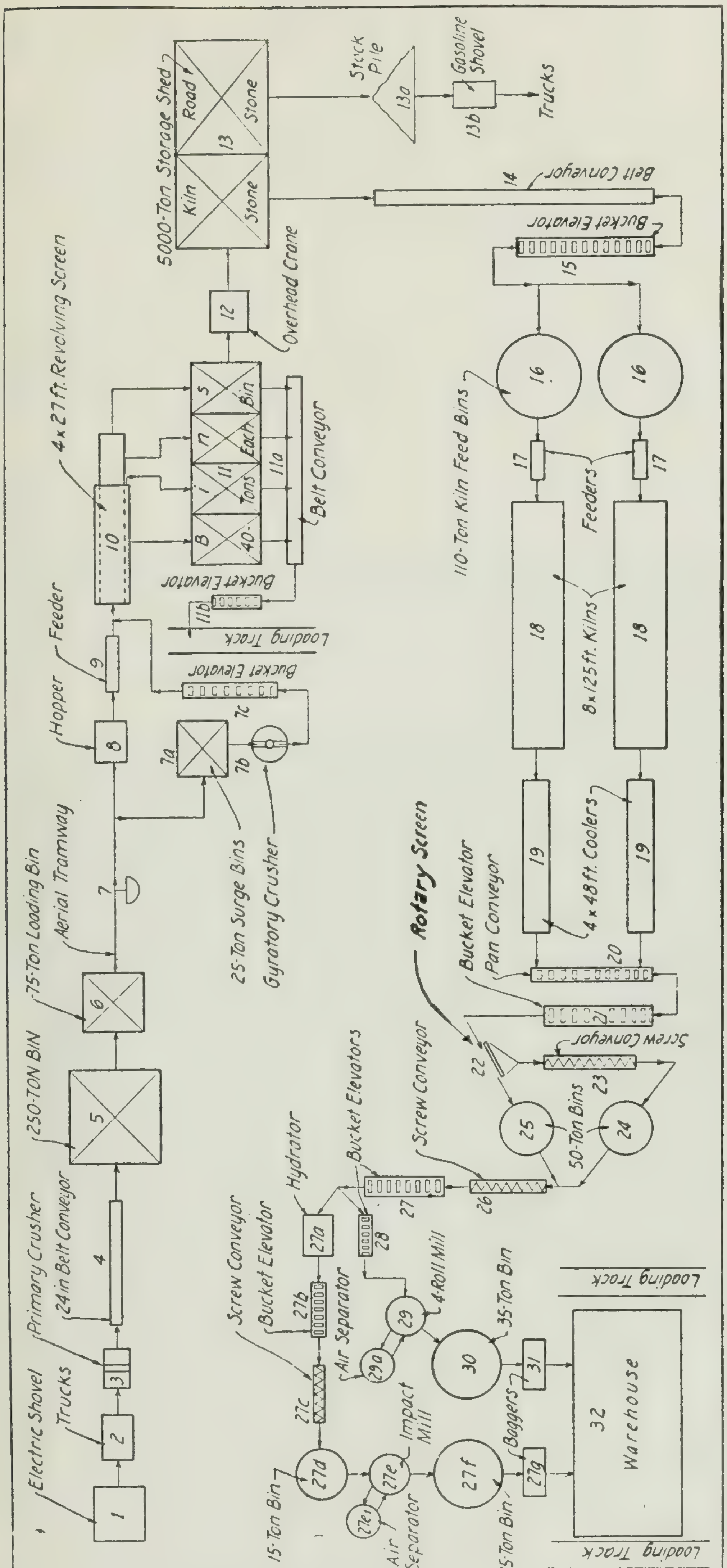
of the Calaveras (Carboniferous) formation and enclosed in amphibolite schist. The strike is nearly north, and dip steeply east, nearly vertical. A pit from 100 ft. to 120 ft. deep and 80 ft. wide has been opened on a level a little above the mill and kilns. After drilling and blasting the south face, 6 men break the rock to 1-ft. size or less, with sledges and tram it several hundred feet to the plant. A Dixie mill with a capacity of 8 tons an hour is operated by a 40-h.p. electric motor. It reduces the coarse rock to about 20-mesh for glass factories. Two lime kilns in commission burn about 10 tons of rock each day. They use oil brought to the plant in tank trucks from Stockton for fuel.

There is a small plant for preparing hydrated lime, and prepared lime is also sold. Sales are made to mine cyanide plants and to farmers for use in fruit-tree spray and as a soil corrective. From 14 to 18 men are employed.

Diamond Springs Lime Company is an Ohio corporation, operating a large modern lime plant at Diamond Springs. The supply of limestone comes partly from their own quarry, 3 miles east of the plant and in part is purchased from *El Dorado Limestone Company* (which see). Homer P. Brown is general manager. R. J. Finchley is the general superintendent and R. V. Whigham is assistant superintendent. The main office is at Diamond Springs. The plant was established in June, 1927.

Limestone from the company's own quarry carries considerable magnesium carbonate. The deposit is covered by a soil and clay overburden about 8 ft. deep, which is stripped during the off-season with the Link-Belt electric shovel used for digging and loading limestone. The total amount of limestone in the deposit is not known, though it is said to have been drilled to a depth of 600 ft. It has been stripped 200 ft. wide by 500 ft. long. A face 36 ft. high is broken by drilling with Jackhammers using 36-ft. steel in vertical holes. With a higher face, these are supplemented by flat holes drilled from near the bottom. The vertical holes are spaced 10 ft. apart in two staggered rows, and are shot with 40% Trojan bag powder, which is said to give $4\frac{1}{2}$ tons of broken stone to 1 lb. of powder. Stone is loaded into trucks and hauled to the primary crusher, going thence by belt conveyor to bins. An aerial tramway 3 miles long, with 149 buckets of 800 lb. capacity delivers about 250 tons of limestone to the plant in an 8-hour shift.

The tabular analysis and flow-sheet, taken from an excellent article published in ''Pit and Quarry'' April 6, 1932, gives details of the principal operations as carried on now, except that the vibrating screen for sizing quicklime has been replaced by a rotary screen. The plant is one of only three in the country using rotary kilns for burning limestone. Each of the 8-ft. by 125-ft. kilns requires from 3 to $3\frac{1}{2}$ hours to turn out 12 tons of finished lime. In all, 13 grades of lime and 3 of hydrated lime are produced. Kilns are inclined $\frac{1}{2}$ inch to 1 ft. and are driven at a speed of from $\frac{1}{6}$ r.p.m. to $\frac{1}{2}$ r.p.m. Oil fuel is fed at 225 lb. pressure and 280° F. The kiln temperature varies from 1800° F to 2200° F at the firing end, and is about 1300° F at the feed end. The oil feed is controlled by valves with micrometer adjust-



Flow sheet, Diamond Springs Lime Company's plant, El Dorado County.

ment. About 50 gallons of fuel oil is required per ton of lime. Each kiln is operated by a 25-h.p. electric motor.

Electric power is supplied by Pacific Gas and Electric Co. through a special automatic sub-station adjoining the works, which is fed by two 60,000-volt lines. This steps down power to 11,000 volts and is transformed to 440 volts for plant and quarry use. Oil for fuel is brought in tank cars over the Southern Pacific tracks serving the plant, and the high-calcium limestone supplied by El Dorado Limestone Co. also comes in by rail.

From the kilns, the lime passes through rotary coolers, over a pan conveyor to a bucket elevator and to the top of the hydrator building. The oversize (over ½ inch to 1½ inch) is used for quicklime and the fines for hydrated lime. A large part of the quicklime is ground in a Raymond 4-roller mill, which yields a product nearly all passing 100 mesh.

An important market for high-calcium quicklime is for steel fluxing, while lime made from magnesian limestone can be used in building; but other uses are numerous, including the cyanide process of gold extraction, water purification and the making of paper and strawboard.

An interesting side-line, utilizing waste products, is the manufacture of targets (clay pigeons) at this plant. A subsidiary, *El Dorado Chemical Company,* manufactures a heat-resisting aluminum paint.

In all, 72 men are employed, of whom 55 work in the plant and 7 in the quarry.

El Dorado Limestone Company has 465 acres 4½ miles by road southwest of Shingle Springs where limestone mining has been going on for 25 years. In earlier days, stone from the deposit was used to make lime for building purposes. *El Dorado Lime and Minerals Company* was the immediate predecessor of the present company, and their operations were described in our Report XXII for 1926. The present company was formed in 1931. J. H. Bell, general manager, has been in charge of operations for many years for this and the preceding companies. The company has a right-of-way with 1.9 miles of standard gauge spur track connecting with the Placerville branch of the Southern Pacific Railroad.

The deposit occurs in a series of lenses of white, high-quality limestone dipping 85° east in a belt of Calaveras (Carboniferous) rocks from ¼ mile to ½ mile wide. The lenses are separated by strips of the country rock and in places small dikes cut across the limestone. For many years two lenses have been mined by shrinkage stoping and by using benches or slicing and underhand stoping. Drifts 20 ft. wide by 8½ ft. high have been run. Widths worked have ranged generally from 20 ft. to 70 ft. The object has been to make as much lump rock as possible. Coarse rock is drilled and blasted in the stopes and is broken again by hand with sledges on the grizzleys over the loading pockets at the shaft.

The mine has been opened through a 3-compartment vertical shaft 500 ft. deep with levels at 150, 300 and 470 ft. This shaft is lined with concrete to the first level.

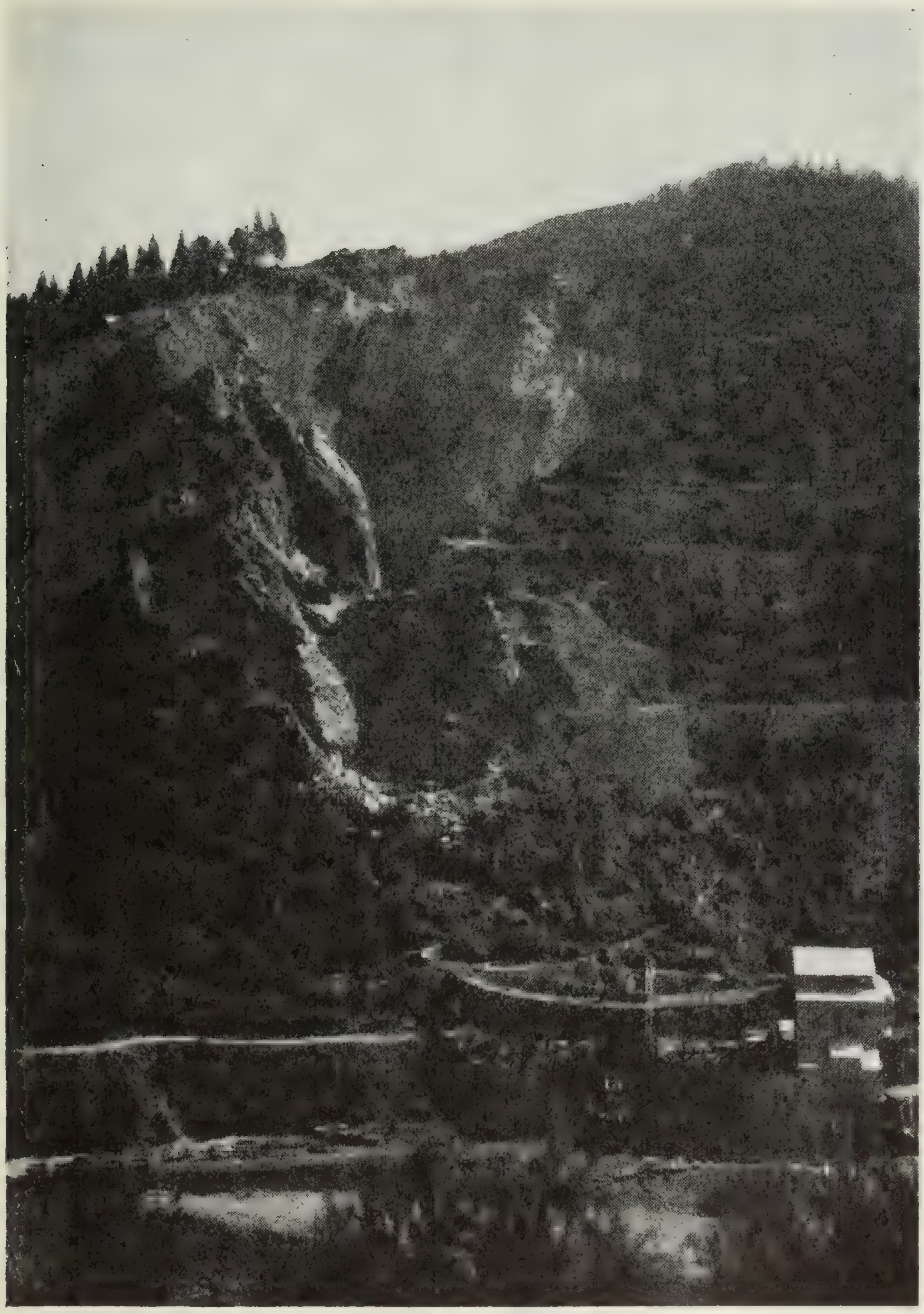
The limestone is solid, without gouges on the walls, and stands well without timber. A length of 300 ft. on the strike and a total

width of up to 120 ft. has been opened, but the total extent of deposit has not been revealed. Dynamite of 25% strength has been used. After hoisting, rock is screened to different sizes, some being crushed as fine as 20-mesh. Electric power is used throughout.

Because of its purity the limestone is put to various uses. Lump stone is sold to the steel mills and smaller sizes go into paint, kalsomine, glass-making, the sugar industry, etc.

About 40 men have been employed lately and the property has been the largest producer of 'industrial' limestone in the state with an output of around 100,000 tons a year.

Henry Cowell Lime and Cement Company, 2 Market Street, San Francisco, owns 885 acres of land in secs. 7, 8, 18, and 30 T. 12 N., R. 9 E., on which there is a large deposit of limestone. This is from ½ to 2 miles north of Cool, on and near the road to Auburn, and was mentioned in old reports as the Cave Valley Limestone Quarry or Blue Marble Quarry.



Mountain quarries (limestone) of Pacific Portland Cement Co., near Cool.

TABULAR ANALYSIS OF THE OPERATIONS AND EQUIPMENT OF DIAMOND SPRINGS LIME CO. PLANT AT DIAMOND SPRINGS, CALIFORNIA

(The key numbers refer to the equipment shown on the accompanying flow-sheet)

Operation	Key	Equipment	Make	Model No., size, capacity or type	Power source	Power transmission
Raw-material recovery and transportation	1	Shovel	Link-Belt	1¼-cu. yd. electric	60-hp. G. E.	Link-Belt silent-chain
	2	Trucks (2)	International	5-ton		
Primary crushing	3	Primary crusher	Allis-Chalmers	40-in. by 42-in. jaw	150-hp. G. E. slip-ring	Belt
	4	Belt-conveyor	Stearns	24-in. by 180-ft.	15-hp. G. E.	Belt
	5	Bin		250-ton		
	6	Loading bin		75-ton		
Transportation	7	Aerial tramway (Optional to 7a)	Am. Steel & Wire Co.	50-ton per hr.	40-hp. Westinghouse induction	Belt
	8	Hopper				
	9	Feeder	Link-Belt	Reciprocating type	5-hp. Westinghouse	Link-Belt silent-chain
Screening and storage	10	Revolving screen	Link-Belt	4-ft. by 27-ft.	15-hp. Westinghouse	Link-Belt silent-chain
	11	Bins (4) (Optional to car-loading 11a)		40-ton each		
Recrushing	7a	Surge-bin		25-ton		
	7b	Reduction crusher	Telsmith	8-in. gyratory	50-hp. Westinghouse	Belt
	7c	Bucket-elevator (To screening and storage 10)	Link-Belt			
Car-loading	11a	Belt-conveyor	Link-Belt	36-in. by 250-ft.	10-hp. Westinghouse	Link-Belt silent-chain
	11b	Bucket-elevator	Link-Belt			
Storage	12	Overhead crane	Judson Pacific Co.	1½-cu. yd.	2 50-hp., 1 15-hp., 1 5-hp.	Gears
	13	Open storage (Optional to stock-piling 13a)		5,000-ton		
Stock-piling	13a	Stock-piles				
	13b	Shovel	Northwest	¾-cu. yd. gasoline		

Reclaiming	14	Belt-conveyor	Link-Belt	24-in. by 40-ft.		
	15	Bucket-elevator	Link-Belt	67-ft.	10-hp.	Link-Belt silent-chain
	16	Kiln-feed bins (2)	Link-Belt	110-ton circular		
	17	Feeders (2)	Link-Belt	Belt-type	Kiln drive	Chain and reeves variable speed transmission
Calcining	18	Kilns (2)	Vulcan	8-ft. by 125-ft.	25-hp. variable-speed	Link-Belt reducer and gears
	19	Coolers (2)	Vulcan	4-ft. by 48-ft.	15-hp. Westinghouse	Belt and gear
	20	Pan-conveyor	Link-Belt		5-hp. Westinghouse	Chain and gear reducer
	21	Bucket-elevator (Optional to quicklime screening and storage 23)	Link-Belt	60-ft.	7½-hp. Westinghouse	Link-Belt silent-chain
Quicklime screening and storage	22	Rotary screen (Oversize to 25, throughs to 23)	Link-Belt	3-ft. by 6-ft. single-deck	2-hp. Westinghouse	Belt
	23	Screw-conveyor	Link-Belt		5-hp. Westinghouse	Link-Belt reducer and silent chain
	24	Bin	Link-Belt	50-ton capacity		
	25	Bin	Link-Belt	50-ton capacity		
	26	Screw-conveyor	Link-Belt			
	27	Bucket-elevator (Optional to hydrating 27a)	Link-Belt			
	28	Bucket-elevator	Link-Belt	40-ft.	5-hp. Westinghouse	Link-Belt silent-chain
Quicklime pulverizing and packing	29	4-roll mill	Raymond	4-roller	50-hp. Westinghouse	Belt
	29a	Air-separator	Raymond	No. 11 Exhauster	40-hp. Westinghouse	Belt
	30	Bin	Link-Belt	35-ton capacity		Belt
	31	Bagger (To storage for shipment 32)	Valve Bag Co.	4-bag	7½-hp. Westinghouse	
Hydrating	27a	Hydrator	McGann-Schulthess	6-t.p.h. capacity	15-hp. G. E.	Famous worm reducer and gear
	27b	Bucket-elevator	Link-Belt	40-ft.	7½-hp. Westinghouse	
	27c	Screw-conveyor	Link-Belt			
	27d	Bin	Link-Belt	15-ton capacity		
Hydrated-lime grinding and packing	27e	Impact mill	Raymond		20-hp. Westinghouse	
	27e	Air-separator	Raymond	No. 12 Exhauster	50-hp. Westinghouse	Direct-connected
	27f	Bin	Link-Belt	25-ton capacity		
	27g	Bagger (To storage for shipment 32)	Valve Bag Co.	4-bag	7½-hp. Westinghouse	Belt
Storage for shipment	32	Warehouse		50-ft. by 90-ft.		

Many years ago lime kilns were operated here but nothing has been done recently. Superficially the deposit appears as large as the one being worked by Pacific Portland Cement Company on the north. A quarry face perhaps 200 ft. high could be opened from the north.

The same company owns another limstone deposit near Marble Creek, 3 miles east of Clarksville, and limestone was burnt there years ago. This also is idle.

Mountain Quarries, Pacific Portland Cement Co., owner. At the north boundary of the county, on the south slope of the canyon of Middle Fork of American River 4½ miles from Auburn. The company has its own broad-gauge railroad 7 miles long connecting with the Central Pacific old main-line a mile west of Auburn.

This, the largest limestone producer in northern California, has been in operation intermittently but for a part at least of nearly every year since 1910. It has been frequently described. The deposit is the southern part of a large lens of limestone divided and partly eroded away by the river. The outcrop was about 1 mile long north to south, and about two-thirds of the deposit was on the El Dorado County side. The lens stands nearly upright with a width of from 300 ft. to 400 ft. and was proved to a depth of 800 ft. The series of limestone lenses extending across the county, of which this is one, have been classified as being in the Calaveras formation (Carboniferous).

This deposit has been worked through an adit 10 ft. by 14 ft. in cross-section, 70 ft. above the river. After clearing the overburden with a steam shovel, raises were put up from the adit level and glory holes were opened. The broken stone is dropped down the raises to 6-ton cars on the adit level from which it is hauled to the crushers and sizing plant. Most of the stone in years past went to the company's cement plant at Cement, Solano County, at the rate of from 1200 tons to 1500 tons a day. Lately the cement plant has been idle and sugar companies have been the principal customers. A sugar refinery requires a large tonnage of limestone during a short working season, so the deposit is worked only part of the time.

The operations were described in detail by Geo. J. Young in 'Engineering and Mining Journal Press' July 4, 1925.

ADDENDA

See pp. 363, *et seq.*, for additional data on El Dorado County mines.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

The Geologic Branch endeavors to secure from outstanding and authoritative scientists and engineers, articles of a more general or popular nature so that the general reader may benefit by this broader point of view than may be acquired by perusing only the intensive technical accounts and inventories of facts.

IN THIS ISSUE

Strategic Minerals:

The possibility of war interfering with the importation of much-needed raw materials which are not now produced domestically in sufficient quantity, has brought up again the subject of strategic minerals. At the request of the Geologic Branch, Mr. Charles White Merrill, engineer of the U. S. Bureau of Mines as well as of the U. S. Army Reserve, has prepared and generously contributed for our publication the following timely paper—''Strategic Minerals in California''—explaining what conditions the country would be facing and how California can help in the case of another international disturbance.

Mineral Highlights:

In a period of over 30 years, our State Mineralogist, Mr. Walter W. Bradley, has had the opportunity of following with close interest the discovery and utilization of a long list of minerals and mineral products of California. It seemed in order, therefore, since we have finally published an up-to-date, detailed account of all the mineral species known in the state through Bulletin No. 113 (''Minerals of California'' prepared by Professor Adolf Pabst), that Mr. Bradley should relate to us from first-hand knowledge some of the ''Mineral Highlights of California.'' This he has done, bringing forth the salient points in the history of the state's mineral development. He gives due credit to the extremely diversified geological features of California (as shown on the new State Geologic Map) as being responsible for the diversity and abundance of minerals.

Submarine Canyons:

In the ample margin of Sheet No. III of the new Geologic Map of California, appears a much smaller state map entitled, ''Geomorphic Map of California.'' Faults, physiographic boundaries, and surface contours are shown on it, also submarine contours indicating the irregular configuration of the underseaground surface. What is generally regarded as the continental shelf is that part which is not over 100 fathoms (600 feet) below sea level. Beyond this depth, the submarine topography shows marked ruggedness of character and in

many places extremely deep canyons which extend far out to the west. These are much like the canyons formed on continental surfaces, especially along the margins of upraised plateaus, or where rivers cut deep and irregular canyons across a table-land. The submarine canyons of California, clearly shown by the 250-fathom (1500-feet) contours on this map (drawn from new and accurate data of the U. S. Coast and Geodetic Survey), have been and now are being carefully studied in minute detail by the well-known oceanographer, Dr. Francis P. Shepard. At the request of the Geologic Branch, Dr. Shepard has prepared a brief account for the general reader of some of the results of his work in California. He also discusses various theories of how these submarine canyons may have been formed. This study has been made all the more fascinating by the fact that newer methods of undersea investigation are rapidly being developed. There is a vast wealth on the sea bottom in the nature of treasures which have gone down with sinking vessels and probably a still greater wealth in the undiscovered oil pools that lie in the geological structures beneath the bottom of the sea, especially off the coast of southern California.

STRATEGIC MINERALS IN CALIFORNIA [1]

By Charles White Merrill [2]

In the strategy of modern war much attention is given to the possibility that victory or defeat may hinge upon the availability to the combatants of commodities essential to the war industries. Although the United States is particularly favored in its domestic supplies of raw materials, there are, nevertheless, several deficiencies in its resources. These shortages were revealed during the World War, when desperate measures were taken to meet the wartime needs with the result that prices of certain commodities rose to fantastic levels. During that period, California played a very important part in supplying a number of products that had been produced in negligible quantities before the emergency; furthermore, it seems probable that the resources of the State will be called on again should war curtail the flow of commodities from foreign sources.

There are two principal factors in determining the importance of a commodity in the strategy of war. The first consideration is whether or not the commodity is necessary, either directly or indirectly, for the waging of war; the second consideration is whether or not the commodity can be produced in sufficient quantities from domestic sources. It must be borne in mind that to wage war successfully, the military powers must have popular opinion in their favor. Civilian requirements during a time of stress are just as important as are those of the army and navy. After eliminating from consideration those commodities unnecessary to the war industries, it is found that there are wide variations in the surpluses or deficits of the remaining raw materials in any particular country. Here again, those commodities of which there are exportable surpluses or even those of which there are adequate supplies need be given no further consideration from the standpoint of war strategy. Those essential commodities, however, of which there is any deficiency, are termed "critical materials"; those of which there is a marked deficiency are spoken of as "strategic materials." It is obvious that each nation would have a different list of strategic commodities because of the uneven distribution of the world's natural resources.

The Commodities Division of the Army and Navy Munitions Board recognizes 52 materials as being critical; among them are found 22 that are derived from minerals. The board, in preparing for the defense of the United States, listed on September 16, 1937, the following 22 commodities[3] as strategic materials:

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[1] Published by permission of the Director, Bureau of Mines, U. S. Dept. of the Interior.

[2] Supervising Engineer, San Francisco office, Mineral Production and Economics Division, Bureau of Mines, and Captain, Specialist Reserve, U. S. Army.

[3] Those mineral commodities with production records and known reserves in California, superior to any other State, are printed in bold type and those with lesser but appreciable reserves in California are printed in italics.

Aluminum	*Manganese, ferro-grade*	Quinine
Antimony	Manila fiber	Rubber
Chromium	Mica	Silk
Coconut shells	Nickel	Sisal
Coffee	Opium	Tin
Hides	Optical glass	*Tungsten*
Iodine	**Quicksilver**	Wool
Jute		

It will be noted that half of these commodities are either the products of mines or of mineral origin.

There are four methods that should be considered for supplying the deficiencies—the maintenance of trade routes, the use of substitutes, the collection of stockpiles during peace time, and the development of domestic resources. The possibilities of maintaining trade routes depend on many factors. In some cases, routes are easy to keep open where the material is available in a neighboring friendly nation. It is difficult, for instance, to conceive of conditions under which the nickel resources of Canada or the sisal production of Mexico would not be available to the United States in time of war as they are in peace time. Even the manganese resources of Cuba could be obtained with a relatively small expenditure of sea force for their convoy to American ports. Much more difficult, however, would be the problem of assuring passage of tin from British Malaya and the Dutch East Indies were this country at war with a nation or group of nations possessing a powerful navy.

For many years, Great Britain was able to maintain a navy capable of securing its sea lanes against any combination of non-British fleets, but such supremacy is no longer held by any nation. It is obvious, therefore, that sole reliance can not be placed in the maintenance of sea routes although under most conceivable circumstances the United States would occupy an enviable position with respect to sea power. On the other hand, it is obvious that the diverting of naval vessels for convoy service deprives the battle force of part of its strength.

A second defense against the deprivation of strategic materials is the development of substitutes. In some cases, substitutes may prove entirely adequate, but it is generally found that substitution is successful for only a relatively limited number of uses to which a commodity is put. Consequently, substitution, while always an important factor in meeting emergencies, is very seldom a satisfactory solution of the problem. Even where substitutes are developed that meet all the tests that can be given them in laboratories, it is usually found that when quantity production is attempted there remain many problems yet unsolved. It must also be borne in mind that little time is available for such developments in time of war. Moreover, it is usually found that an inferior type of workmen and supervisors is available to industry after the army demands for officers and soldiers are met, which results in additional difficulties when any deviations from routine procedure are proposed.

A third method of meeting the problem is stockpiling. So far most stockpiles that have been suggested as practicable from an economic standpoint have provided only for a short period, after which

it was assumed that the problem could be met by some other method. However, in the case of opium and its derivatives (morphine, heroin, etc.), drugs essential to national defense, a unique situation has provided at least a partial solution to the problem. Narcotics confiscated by the Treasury Department in the enforcement of the Harrison Narcotic Act and the Narcotic Drug Export and Import Law, when of suitable quality, are turned over to the War Department as available stock should normal sources be cut off by an enemy. A serious difficulty sometimes encountered in maintaining stockpiles is that of deterioration. This, however, is of much less consequence in the storing of mineral commodities than agricultural products.

The fourth method of providing supplies of the strategic materials is the development of nonproductive domestic resources. In some cases this method is obviously hopeless, but in many others it offers very great possibilities. There is no chance, of course, that adequate supplies of such commodities as coconut shells, coffee, or chichona bark (source of quinine) could be produced in the United States, largely because of climatic conditions. On the other hand, a number of the strategic minerals are known to occur in large low-grade deposits in various parts of the United States. The development of such resources challenges the mining industry.

Here, again, two points of view have been argued at length. One group holds that bringing such limited resources into production can not help but exhaust them and, consequently, no work beyond prospecting and exploration is desirable. The other group points out that the only practicable way to prove that a deposit can be made productive is to start producing. This group is able to supply many examples of mining camps where the known reserves grew progressively greater as exploitation proceded. The proponents also bring out the fact that the production and preparation of strategic minerals in most cases is largely a foreign industry and, consequently, without some exploitation in the United States, the country must of necessity face a war emergency without technologists and workmen trained in the work. It is also found that domestic product, due to the utilization in many cases of low-grade or impure materials, while satisfactory, may be substantially different from the imported material. It is, therefore, important that consumers of the product be acquainted with the special problems in its utilization. A peace-time industry, even though small, tends to work out such practical problems. It is found, also, that commercial organizations established to exploit the deposits act as focal points for research, which tremendously increases the possibility of solving the special problems of the industry.

Several methods are available for the fostering of such developments. One that so far has been applied is the protective tariff. Time alone will tell whether this has or has not been a wise method. A sizeable production of such metals as quicksilver and tungsten has been maintained since the tariff was enacted, but, on the other hand, the maintenance of production has been attained only by advance in price.[4] Tariff acts for many years have provided a duty of 6 cents a pound on pig tin and 4 cents a pound on tin concentrates effective as soon as the domestic industry reached an annual output of 1,500 long tons

[4] Mercury: U. S. Bur. Mines Minerals Yearbook 1937, pp. 685-686.

of metal. This, however, has not proved a sufficient incentive to expand domestic output.

Agencies such as the United States Bureau of Mines and the United States Geological Survey have played their part in trying to solve the problem of bringing domestic reserves of strategic minerals into production. Deposits have been examined and reported upon. Metallurgical and ore-dressing methods have been devised and tested, and the economic and commercial possibilities of the situation, both from a domestic and world standpoint, have been considered and delineated. State agencies, including the Division of Mines of California, have played an important part in these studies, both in cooperation with the federal agencies and through independent investigations. Funds for such work, however, have been very limited. Like so many government activities predicated on prospective emergencies, great difficulty is experienced in arousing interest in the problem until the emergency is at hand. Unfortunately, action may then come too late.

California's Resources of Strategic Minerals

Probably no state offers as great possibilities for supplying the nation with strategic minerals as does California. Although its resources of aluminum, antimony, sheet mica, nickel, and tin are negligible, it is a leading producer of the country's chromite, iodine, quicksilver, and tungsten; its reserves of low-grade manganese are large; its production of tin, though negligible, exceeds that of any other State; and the possibility of finding minerals suitable for optical-glass manufacture is not hopeless.

Aluminum. Aluminum is of great importance to the war industries because its light weight combined with strength makes it essential in the construction of many kinds of machines. The rapidly expanding motorization of army transport and the tremendous increase in military aviation call for increasingly greater supplies of the metal and its light-weight alloys.

The production of aluminum in the United States is nearly sufficient to meet domestic consumption. In addition, Canada has a large exportable surplus of virgin aluminum metal manufactured in its plants, which would almost certainly be available to the United States in case of war. The difficulty in the aluminum situation, however, lies in the maintenance of the flow of bauxite into the United States, the only ore from which any quantity of aluminum is derived. In 1937 the United States imported over half of the bauxite it consumed. The proximity of the Canadian industry does not relieve the situation, because the manufacturers there must import virtually all of the bauxite they treat.

In the United States the principal bauxite deposits lie in Arkansas, although small productions have been coming from Alabama and Georgia for a number of years. Until some method is worked out to produce aluminum from one of the other aluminum-bearing minerals (clay, for example), any likelihood that California will play an important part in the aluminum industry is small. Although cheap electric power is available, neither bauxite nor most of the other min-

eral commodities necessary to aluminum metallurgy are commercially available in California.

Antimony. Antimony finds a very wide use in industry; its military uses, though more restricted, are essential. It is used in shrapnel, bullets, primers, cable coverings, and to produce white smoke in range finding.

Until very recently, the bulk of the antimony imported into the United States came from China. In 1929 about 70 per cent of all the antimony imported came from China, but in 1936 less than 10 per cent was of Chinese origin and approximately 90 per cent came from Mexico and South America. From a military standpoint, this shift of source has strengthened the American strategic position because trade with points in the Western Hemisphere would almost certainly be easier to maintain than trans-Pacific shipping. The adequacy of antimony reserves in the Western Hemisphere, however, has not been thoroughly investigated. The production of antimony from domestic ores is small and the larger part of it comes from antimonial lead ores. The known resources of straight antimony or antimonial lead ores in California [5] are too small to be of any great consequence even as an emergency supply of the metal.

Chromium. Chromium is of prime military importance as a raw material because it is an essential ingredient in making alloy steels. The chief military uses of chrome alloy steels are armor plate, projectiles, high-speed cutting tools, automobile axles, and springs. Chromium and its derivatives also find wide use in the manufacture of refractories, in chemicals for tanning leather, and a number of other uses of great military importance.

Chromite, the only ore of commerce from which chromium is produced, is mined and exported in large quantities from the Union of Socialist Soviet Republics, Turkey, Southern Rhodesia, Union of South Africa, and New Caledonia. The United States imports almost half of the world's supply.

The production of chromite in the United States has been negligible since the World War period. At that time, however, the domestic industry made a very creditable showing largely due to the production in California.[6]

In 1914 domestic sales amounted to 591 long tons valued at $8,715, but in 1918 sales rose to 82,430 long tons valued at $3,955,567. Imports in 1918 totaled 100,142 long tons valued at $2,892,825. After 1918, however, domestic production sank to almost nothing but imports have increased in both quantity and value.

Under the stimulus of high prices, a large number of small lenses of high-grade chromite were discovered and mined in California, and there seems no reason to believe that similar conditions would not lead to the discovery of many more such deposits in case of another emergency. Moreover, the experience of the World War period tended to define the more favorable localities in which to prospect for the ore. In addition to lenses of rich ore, other areas have been found containing

[5] Boalich, E. S., and Castello, W. O., Antimony, Graphite, Nickel, Potash, Strontium, and Tin: California State Mining Bureau, Preliminary Report No. 5, 1918, 44 pp.

[6] Bradley, W. W., Huguenin, E., Logan, C. A., Tucker, W. B., and Waring, C. A., Manganese and Chromium in California: California State Mining Bureau, Bull. 76, 1918, 244 pp.

extensive deposits of lower-grade material, which undoubtedly could be concentrated and briquetted were prices high enough to justify the cost.

Adequate supplies of high-grade foreign ore available at low cost on the Atlantic seaboard has left little incentive for the development of the California industry. Nevertheless, the local reserves are certain to prove an important factor in furnishing this strategic mineral commodity should war conditions again interfere with the flow of foreign supplies.

Iodine. Iodine continues to be one of the most important drugs for emergency use and is essential in the treatment of battle casualties. Until recently, over half of the world's supply came from Chile and the second most important center of production was Scotland.

Except during the World War period, little iodine had been produced commercially in the United States prior to 1932; during the war, a small output of iodine was derived from kelp at plants on the California coast. Experimental work has shown, however, that iodine can be extracted profitably from certain brines and oil-well waters, with the result that three plants are now recovering iodine from oil-well brines in Los Angeles County, Calif. In 1937, the production of iodine in the United States was a little less than one-sixth as great as the imports.

Manganese. Although manganese, both in quantity and cost, is a very minor raw material in the steel industry, it is nevertheless absolutely essential to the making of good steel. On the average, approximately 14 pounds of manganese is consumed in each ton of finished steel. There are several types of manganese ore used commercially, but the type that the war industries are principally interested in is termed "ferro-grade." Ore to be ferro-grade must be high in manganese and low in phosphorus and sulphur. It is the use of manganese in the making of steel, of course, that gives it its strategic significance. As modern war can not be waged without huge supplies of steel of the highest grade, and as high-grade steel can not be made without manganese, it is obvious that this metal is one of the most important on the list of strategic mineral materials.

The Union of Socialist Soviet Republics, Gold Coast, Cuba, Brazil, and India are the principal sources of the manganese imports of the United States. These countries, together with the Union of South Africa, Egypt, and Japan, are the principal producers of manganese ore. Unfortunately, with the exception of Cuba and Brazil, the sources of production are remote and the sea lanes that would have to be kept open for importation of the ore would prove difficult to defend.

A most inviting possible solution of the manganese problem lies in the development of a commercial process utilizing low-grade domestic manganese ores where ferro-grade manganese ore is now used. During 1936, the United States Bureau of Mines announced[7] the development in its laboratories of a method for producing metallic manganese by the electrolysis of manganese-bearing solutions. As these solutions may be had from the leaching of low-grade manganese

[7] Shelton, S. M., Electrolysis of Manganese Solutions, Progress Report 13 Metallurgical Division: Rept. of Investigations 3322, Bureau of Mines, 1936, pp. 29-37.

ore, renewed hope has been expressed for the utilization of low-grade manganese deposits in ferrous metallurgy. At present, however, the bureau's process is still in the laboratory stage and no dependence should be placed on it as a solution of the manganese problem.

A number of manganese deposits are known in California,[8] and ore, both low-grade and ferro-grade, has been produced, particularly during the World War period. The known reserves of the State are not great, but further exploration and development might extend them considerably. Any California manganese industry, however, whether in war time or peace time, faces one very serious handicap—the transportation costs between California and the principal iron and steel manufacturing centers are very great. In some cases, the freight costs on California ore alone exceed the delivered price of high-grade manganese ore of ferro-grade from foreign sources.

Mica. It is the electrical properties of sheet mica that place this mineral on the list of strategic minerals. Sheet mica is used as an insulator in the automobile, airplane, and radio industries, all three of which are of great importance from a military standpoint. Over three-fourths of the sheet mica of the world is produced in India; Madagascar and the United States follow India in quantity of output.

The known reserves of sheet mica in the United States are small, and the industries using sheet mica have depended largely on imports for many years. Mica suitable for grinding occurs extensively, however. California has never had a sheet-mica industry and its known resources of this material are negligible. There are areas, however, where general geological considerations indicate that prospecting might not be fruitless. The granite and pegmatite areas of San Diego County deserve attention.

Nickel. The principal military use of nickel is as an alloying metal for steel. Virtually all armor plate is made of nickel steel. Canada is by far the largest producer of nickel, and fortunately the Sudbury district, where virtually all of it is produced, has always been easily accessible to American industry. The second largest producer of nickel is New Caledonia in the south Pacific Ocean.

The production of nickel from nickel ore in the United States has been negligible and no reserves are known that offer much possibility of yielding any appreciable quantities of this metal. The very small production of nickel reported each year comes from copper refineries, where it is a byproduct of copper mining. Even the byproduct nickel can not be fully credited to domestic mines, because some of the blister copper richest in nickel is imported into the United States for refining. California[9] offers no special prospect for developing a domestic supply of this metal.

Optical glass. The problem of supplying optical glass for such military needs as range finders and field glasses is largely one of manufacturing. Under present technology, the constituents of optical glass must be melted in kaolin pots that have been permitted to cure for at least eight months. Although the task of finding domestic sources of raw material for optical-glass manufacture probably would not offer

[8] See footnote 6, p. 287.
[9] See footnote 5, p. 287.

serious difficulties in peace time, the necessity of locating such supplies under war time stress might very probably cause dangerous delays. The search for the materials undoubtedly would be directed to many parts of the United States, but it seems likely that regions like the pegmatite areas of San Diego County, Calif., would receive special attention.

Quicksilver. The principal use of quicksilver in military art is as an ingredient of certain explosives like mercury fulminate, small quantities of which are used in the detonators that start many of the projectiles on their way. For a number of years Spain, Italy, and the United States had been the leading producers of quicksilver, but present war conditions in Spain make it impossible to ascertain the exact recent production in that country.

At the present time California[10] produces more quicksilver than all the rest of the United States together. Although the occurrence of quicksilver is such that blocked-out ore reserves are almost invariably small, there seems to be little reason for expecting California quicksilver production to decline seriously as long as the price and costs remain within the limits of economic ratio. Moreover, geologic considerations lead to the conclusion that the coast ranges of California form a quicksilver province from which a yield of the metal may be expected for many years. It was found during the World War that the stimulus of a higher quicksilver price caused a large increase in the production of the metal, and it seems probable that the miners of California would do much to provide the needed volume of this strategic metal if its price were sufficiently increased.

Tin. Tin has a very large number of military uses; it is a constituent of babbit bearings used in engines of airplanes, tanks, trucks, automobiles, motorcycles, tractors, and other essential military machines. In addition, any nation that depends on an army made up almost entirely of hastily-trained civilians must plan to provide them with easily digestible food. Under field conditions, food preserved in tin cans is the obvious solution to this problem.

The largest source of tin ore is southeastern Asia, where British Malaya, Netherland India, Siam, China, and Burma produce almost three-fourths of the world's supply. Bolivia, in South America, and Nigeria and Belgian Congo, in Africa, are the other principal sources of the metal. The world smelting centers are situated in British Malaya, the United Kingdom, the Netherlands, Netherland India, and China. The United States had a large smelting industry, depending principally on Bolivian tin concentrates, during the World War, but this domestic industry found itself unable to compete with foreign smelters after 1924, due principally to the difference in labor costs.

The production of tin ore in the United States, up until the present time, has been negligible. Surveys of areas where tin has been produced or tin minerals have been reported, particularly during the period of the World War, have revealed nothing to sustain the hope that any appreciable quantity of tin will ever be produced in the United States. The production of about 100 long tons of tin at the

[10] Bradley, W. W., Quicksilver Resources of California: California State Mining Bureau, Bull. No. 78, 1918, 389 pp.

Temescal (Cajalco) mine in Riverside County, Calif.,[11] since its discovery in 1840 probably exceeds the sum of the productions of all the other domestic properties outside of Alaska. The principal contribution towards tin production in California undoubtedly will come from the detinning plants, which reclaim the tin found in tinplate scrap. A plant in South San Francisco, belonging to the Metal and Thermit Corporation, treats large quantities of tinplate scrap, most of which is collected in the can factories serving the huge canning industry of the State.

Tungsten. Tungsten is of tremendous importance to the war industries because of the unique qualities it imparts to tool steels. Tungsten tool steel can be used in high-speed work where the generation of heat brings the tool to a red heat without drawing its hardness. Ordinary carbon tool steel under these conditions becomes soft and worthless almost immediately. In many of the metal-working industries, tungsten tool steel makes possible the speed-up which is so important to profitable industry and absolutely essential to wartime industrial efficiency. China, Burma, the Federated Malay States, Bolivia, and Portugal are the leading producers of tungsten outside of the United States.

Under the protective tariff, the tungsten mines of the United States have been able to supply over half of the industrial needs of the country during the last few years, and California [12] has played an important part in this domestic production. The most important California deposits are situated at the Atolia section of the Randsburg district in San Bernardino County and on the eastern flank of the Sierra Nevada in Inyo and Mono counties. In the former district, both placer and lode ore have been produced.

California in a future emergency. Perhaps the most important factor in meeting an emergency calling for an output of strategic minerals from inactive deposits is detailed knowledge regarding such resources. In addition to its extraordinarily wide assortment of mineral resources, California is very fortunate to have a very large number of mining men, including prospectors, practical operators, mining engineers, and geologists, who have accumulated a vast fund of data regarding the strategic minerals of the State. The existence of this information during the World War was evidenced by the rapidity with which the miners of California began delivering strategic minerals from the mines of the State, notably chromite, quicksilver, and manganese ore. It seems certain that should another emergency arise, a following generation of miners as well informed and as patriotic as those of 1917 and1918 would be found ready to help meet the situation.

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[11] See footnote 5, p. 287.

[12] Boalich, E. S., and Castello, W. O., Tungsten, Molybdenum, and Vanadium: California State Mining Bureau, Preliminary Report No. 4, 1918, 34 pp.

MINERAL HIGH-LIGHTS OF CALIFORNIA

By Walter W. Bradley, State Mineralogist

The new and revised "Minerals of California" (Bulletin No. 113), prepared by Dr. Adolf Pabst, Associate Professor of Mineralogy, University of California, and recently published by the Division of Mines, reveals several, and recalls to my mind other, interesting features in the mineral field in this state. Wm. P. Blake, who as geologist in 1853 accompanied the Lieutenant R. S. Williamson expedition of the Pacific Railroad Surveys, published in 1866 the first list of Californian minerals comprising some 75 species then known in this as yet little-explored territory.

Henry G. Hanks, the first State Mineralogist of California (1880-1886), published a second list of minerals in 1884 as a chapter in the Fourth Annual Report of the State Mineralogist. That list practically doubled the number of species up to that time identified, and gave detailed descriptions of some of the localities as well as data on those particularly of economic value. Thirty years later (1914) the State Mining Bureau issued Bulletin 67, entitled "Minerals of California," written by Dr. Arthur S. Eakle, Professor of Mineralogy in the University of California. In the intervening years much knowledge had been gained of the geology and mineralogy of this state, including the ore deposits of many of the counties, the gem and borate deposits in the southern section, and the petrography of many districts. Eakle's list included at least 300 species, besides subspecies and varieties. A second edition of Eakle's work was published in 1923, as Bulletin No. 91 of the State Mining Bureau, adding still further to our knowledge of California's minerals and cataloguing more details of the localities of occurrences of the economic minerals.

This newest bulletin, by Dr. Pabst, brings our published data down to 1938 and describes over 400 mineral species not including varieties. Of these, 54 were discovered in California, several of them proving of importance commercially, and others of special mineralogic interest. Colemanite, discovered in 1882 and kernite in 1927, has each in its turn been the most important commercial borate mineral, the latter being the principal world-source today. Metacinnabar, discovered in 1870 has yielded important production at times in certain of the quicksilver mines. Lawsonite, first found in Marin County in 1895, has proved to be of great petrographic interest.

The first of the new minerals found in California came, as might be expected, from the gold mining region of the Sierra Nevada, beginning with melonite, the nickel telluride, in Calaveras County in 1867. However, four regions or localities have been the most prolific in yielding new species: the quicksilver mines of the Coast Range north of San Francisco Bay, the saline lake deposits of the desert region, the pegmatite gem-bearing deposits of northern San Diego and adjoining Riverside County, and the metamorphic contact fringe of the limestone deposit at Crestmore in Riverside County. The first-named has accounted for seven new varieties, the second for eighteen, the third for four, and the fourth for nine.

The minerals first found in California and the dates of their published descriptions are as follows:

*Partzite, 1867
Melonite, 1867
*Mariposite, 1868
Calaverite, 1868
Metacinnabar, 1870
*Aragotite, 1873
Roscoelite, 1875
*Posepnyte, 1877
*Ionite, 1878
*Tincalconite, 1878
Colemanite, 1883
*Hanksite, 1884
*Napalite, 1888
Sulphohalite, 1888
*Knoxvillite, 1890
*Redingtonite, 1890
Iddingsite, 1893
Lawsonite, 1895
*Northupite, 1895
Pirssonite, 1896
*Bakerite, 1903
*Boothite, 1903
*Tychite, 1905
*Benitoite, 1907
*Joaquinite, 1909
*Palaite, 1912
*Salmonsite, 1912
*Sicklerite, 1912
*Stewartite, 1912
Inyoite, 1914
*Meyerhofferite, 1914
Searlesite, 1914
*Wilkeite, 1914
*Crestmoreite, 1917
*Griffithite, 1917
*Riversideite, 1917
*Plazolite, 1920
*Vonsenite, 1920
*Jurupaite, 1921
Merwinite, 1921
*Kempite, 1924
*Foshagite, 1925
*Kernite, 1927
*Probertite, 1929
*Curtisite, 1930
Krausite, 1931
*Sanbornite, 1931
*Schairerite, 1931
*Tilleyite, 1933
*Burkeite, 1935
*Woodhouseite, 1937
*Ellestadite, 1937
*Teepleite, 1938
*Veatchite, 1938

Of the above-listed minerals, 41 (marked by *) have not yet been found, so far as known, outside of California.

Of the economic minerals, gold was, of course, as in all new and undeveloped countries, the first to be exploited. Today though California is still the leading state in the Union in gold output, that metal is not now our most valuable product. Petroleum, a mineral substance though not a definite individual mineral, heads California's commercial list. Natural gas, in a similar category, is also important. Other important commercial mineral products such as the building stones, granite and sandstone, are likewise not single minerals but natural mineral aggregates. Diatomite, or diatomaceous earth, is not a distinct 'mineral' but a mixture of fossil opaline silica with variable impurities. California produces on a commercial scale, annually, between 55 and 60 different mineral substances, not segregating the several varieties of gem stones sold, such as the diamond, garnet, tourmaline, chalcedony, et al.

In the mineral industries California is the leading domestic producer of borax, quicksilver, platinum, tungsten, chromite, and magnesite. Some of our gem stones, such as tourmaline and kunzite, are not excelled elsewhere; and in the case of benitoite it has not been found outside of the single locality of its discovery. To our economic list in recent years have been added iodine, bromine, natural carbon dioxide gas, wollastonite, and zircon.

Of borax, California is today the leading world source, as already noted. This mineral was discovered in the waters of Tuscan Springs, Tehama County, January, 1856, and in September of the same year in Borax Lake, Lake County, the latter being worked commercially from 1864 to 1868 inclusive. Production from the 'playa' or dry-lake deposits of Inyo and San Bernardino counties began in 1873, but in 1887 the borax industry was revolutionized by the discovery of the colemanite (calcium borate) beds at Calico, San Bernardino County, and later similar beds in Inyo, Los Angeles, and Ventura counties were utilized. Colemanite was in turn displaced by the discovery in 1926 of kernite (rasorite), a sodium borate, near Kramer in Kern County. Other borate minerals associated with colemanite are borax, inyoite,

ulexite, howlite, meyerhofferite, probertite, hydroboracite. Kernite being a sodium borate with only four molecules of water of crystallization as compared with ten molecules in the borax of commerce, means that in the process of recrystallization approximately one and one-half tons of borax are obtained for each ton of clean kernite mined. Is it any wonder that all other borate minerals were relegated to the background?

California became the leading American producer of mercury, or quicksilver, almost simultaneously with the inception of gold mining here. The New Almaden Mine in Santa Clara County was first worked in a small way in 1824, and its total production has been over a million flasks (of 76 pounds, each), surpassed by only one mine in the world (Almaden Mine, Spain) during the period in which New Almaden operated. Published records show this total, however, has been exceeded also by the Idria Mine in Austria and the Santa Barbara Mine at Huancavelica, Peru, the bulk of whose production was made prior to 1850. The principal mercury mineral of economic value, the world over, is the red sulphide, cinnabar. Metacinnabar has the same composition, chemically, but is black and crystallizes in the isometric system, whereas the red is hexagonal. In certain parts of some of California's mines the black sulphide has constituted important orebodies, but it is usually in minor amounts. Native mercury occurs to some extent in many quicksilver mines, accompanying cinnabar, and generally disseminated in fine liquid globules. In California it seems to be characteristic of the quicksilver deposits within certain serpentine areas, rather than of those outside of the serpentine. The less important mercury minerals, occurrences of which have been noted in California are: amalgam, native alloy of mercury and gold; calomel, mercurous chloride, coccinite, the iodide; coloradoite, the telluride; eglestonite, an oxychloride; montroydite, an oxide; tiemannite, the selenide.

Although California's annual yield of a few hundred fine ounces of platinum-group metals is insignificant compared to the principal world sources, yet that small amount puts this state in the domestic lead. It is practically all obtained as a by-product from the placer-gold operations of the dredges and hydraulic mines. It occurs mostly in grains and occasionally in small nuggets up to at least two or three ounces. Most of the platinum consists of natural alloys with iridium, osmium, palladium, ruthenium, and could doubtless be classified as platiniridium. In fact, the nuggests are in part platiniridium, and some are iridosmine (osmiridium) both of which have a hardness of 6–7, while platinum is only 4–4½. The writer has an osmiridium nugget from Trinity River district which will scratch glass.

Most of California's tungsten ore is scheelite, the calcium tungstate; but wolframite (iron-manganese tungstate) and hübnerite (manganese tungstate) also occur here. Ferberite, the dominantly iron member of the wolframite series so prominent in Colorado, is not known thus far in California. Published data indicate that the deposits at Atolia in San Bernardino County have been the largest and most productive scheelite deposits known, particularly in massive scheelite in veins up to three feet wide.

Chromite (chromic iron oxide), along with magnetite (magnetic iron oxide), is a primary magmatic constituent of such basic igneous

rocks as peridotite, pyroxenite, dunite, which alter readily into serpentine of which there are extensive areas in this state. These two minerals comprise the bulk of the black sands found in nearly all gravel deposits and along the ocean beaches. Chromite has important industrial uses, both as a source of the metal, chromium, for toughening ferro-alloys and as a refractory liner in metallurgical furnaces. It occurs in lenses of massive mineral in the serpentine and as disseminated-crystal orebodies. In the year 1918, due to war-time demand and curtailment of foreign importations, a total of 29 counties in California shipped chromite to a total valuation of over 3½ million dollars.

Magnesite (magnesium carbonate) is another of California's specialties. Commercial production began in the Cedar Mountain district, Alameda County, south of Livermore in 1886, but the shipments were small until 1907. In 1917, owing to war conditions the value reached just short of two million dollars. The first few years it was utilized principally as a source of CO_2 gas, but later for Sorel, or plastic cement and as a refractory.

In her list of gem stones, California has had an interesting history, both mineralogically and commercially. Diamonds were early recognized and recovered in washing the gold-bearing stream gravels, notably at Cherokee, in Butte County, Volcano in Amador County, Smith's Flat in El Dorado County, and French Corral in Nevada County. While mostly small, a number have been over two carats in weight.

Kunzite, a gem variety of spodumene, was first found at Pala in the tourmaline district of northern San Diego County. It has thus far been found in only one locality (Madagascar) outside of California. California's tourmalines are decidedly distinctive in coloring and 'fire' as compared to foreign stones of this classification, the colors ranging from deep ruby to pink, and various shades of green, as well as a blue variety (indicolite).

One of our California gem stones, benitoite, has not been found elsewhere, and in but a single locality here: The Dallas Mine in San Benito County. It is a barium-titanium silicate ranging from colorless to deep blue; and when discovered was thought to be sapphire, but analysis proved it to be a new mineral. Crystallographically it is also interesting in that it is the lone representative of the ditrigonal bipyramidal class of the hexagonal system. Prior to the discovery of benitoite, this crystal class had been projected theoretically by mathematics in accordance with the laws of symmetry.

Beryls of delicate but excellent colors are also obtained in the Pala district, San Diego County, of which the aquamarine (blue) and morganite (pink) varieties deserve special mention. Morganite, like kunzite, has thus far been found elsewhere only in Madagascar. Stones of precious blue topaz of fine quality are being cut from crystals mined in northern San Diego County, being associated with beryl and blue tourmaline.

A small production of tin was made in 1891-1892 and 1928-1929 from the occurrence of cassiterite (the tin oxide) associated with black tourmaline in the Temescal Mine, near Corona, Riverside County.

Common table salt has many other industrial uses besides those that are culinary. In California the bulk of the production, which averages over a million dollars value annually, is obtained by solar

evaporation of Pacific Ocean water. Some is obtained from crystalline deposits in the desert region. From the sea-water plants, by-product magnesium salts (chloride, carbonate, sulphate) and bromine are obtained from the residual bitterns. Iodine is recovered from the saline waters of certain deep oil-wells in the Long Beach area, Los Angeles County.

Aside from those minerals of economic interest and value, some of which are noted in the foregoing paragraphs, California has quite a number that are of mineralogic and scientific interest. Of these, lawsonite (a calcium-aluminum silicate) has already been mentioned.

Troilite, the simple ferrous sulphide, FeS, not previously known except in meteorites has been found and described from northeast of Crescent City, Del Norte County.

We stated that the saline lake deposits of the desert region have accounted for 18 of California's new mineral species. In chronological order they are:

Tincalconite	hydrous sodium borate.
Colemanite	hydrous calcium borate.
Hanksite	a double sulphate and carbonate of sodium with potassium chloride.
Sulphohalite	sulphate, chloride and fluoride of sodium.
Northupite	magnesium carbonate with carbonate and chloride of sodium.
Pirssonite	hydrous carbonate of calcium and sodium.
Bakerite	hydrous calcium silico-borate.
Tychite	carbonate of sodium and magnesium with sodium sulphate.
Inyoite	hydrous calcium borate.
Meyerhofferite	hydrous calcium borate.
Searlesite	hydrous sodium boro-silicate.
Vonsenite	iron and magnesium borate.
Kernite	hydrous sodium borate.
Probertite	hydrous sodium and calcium borate.
Krausite	hydrous iron and potassium sulphate.
Schairerite	sodium sulphate with sodium chloro-fluoride.
Burkeite	double sulphate and carbonate of sodium.
Veatchite	hydrous calcium borate.

Zircon (zirconium silicate) is a common accessory mineral in the acid eruptive rocks, especially granites and syenites. The concentrates from the gold-placer washings and the black sands generally carry some zircon crystals or grains. It was not, however, until the past year that a sufficient quantity has been found present to permit an economic recovery. Zircon sand is now being obtained in commercial quantities in the sluice boxes of the Kaufield dredge, two miles east of Lincoln, Placer County.

Glaucophane, a soda-amphibole rich in alumina and containing little water, is a constituent of metamorphic rocks (particularly schists) high in sodium. Although it is found in many metamorphic regions of the earth, nowhere does it appear to be as common in quantity as a schist as it is in California.

Teepleite is a hydrous sodium borate and chloride. This salt was prepared artificially by John E. Teeple in the course of research work on the Searles Lake, San Bernardino County, brines, and described by him in 1929. When, therefore, in 1937, natural crystals having the same composition were found in Borax Lake, Lake County, associated with trona and halite, the mineral was named Teepleite.

Sanbornite is a white to colorless, translucent silicate of barium, the first simple barium silicate mineral ever found. It was discovered near El Portal, Mariposa County, associated with rose-red gillespite (a rare barium-iron silicate, previously found only as a float mineral on an Alaskan glacier)—and celsian (the barium feldspar, this being its first reported occurrence in the United States). Sanbornite was named for Frank Sanborn, mineral technologist of the State Division of Mines, who made the first qualitative tests on a sample sent in to the laboratory of the division.

The mineral hanksite, a double sulphate and carbonate of sodium with potassium chloride, was named for Henry G. Hanks, the first state mineralogist of California, who occupied the office during the years 1880-1886, inclusive. It was discovered at Searles Lake, San Bernardino County, and later described by Hanks as occurring also, with borax, in the sinks of Death Valley, Inyo County.

Durdenite, a rare hydrous ferric tellurite, though originally discovered (1890) in Honduras was named for Henry S. Durden, for many years curator of the mineral exhibit of the California State Mining Bureau. This mineral was later (1917) identified in a specimen of gold-silver telluride ore from Carson Hill, Calaveras County, in this state.

If one seeks for an explanation of why California has such an abundance and diversity of minerals both of mineralogic and economic interest as well as value, the answer is obtained in a perusal of the geologic map of the state. The formations found in this area run practically the entire gamut of the geological ages from Archean to the present, of igneous, sedimentary and metamorphic rocks. Other states may have more of a given age or era, but few if any can surpass California's diversity. Then, too, being second only to Texas in surface area, we have a lot of territory in which to work.

SUBMARINE CANYONS OFF THE CALIFORNIA COAST*

Francis P. Shepard**

During the past decade there has been an enormous increase in information about the form and general character of the ocean bottom, particularly off the coast of California. With the help of the new scientific devices and a well-formulated plan the United States Coast and Geodetic Survey has produced charts in recent years which, in addition to their navigational value, open up a new realm for scientific speculation.

Not long ago when a captain of a vessel was sent to make a survey in deep water out of sight of land, he was confronted with two serious obstacles. In the first place if the depths were of the order of a mile or more he would have to stop his vessel and spend at least an hour lowering a lead weight attached to piano wire to the bottom and reeling it in again. Having determined the approximate depth by the amount of wire let out, he put this depth on the chart at the position which he thought he was occupying. However, a navigator of a vessel out at sea generally has a pretty inadequate knowledge of his exact position. If it is clear weather at twilight, he can find out where he is within half a mile, and perhaps within five or ten miles during the day time, but except when he can get good radio bearings near shore his position is very uncertain in cloudy weather despite all records of his course and speed. For these reasons the soundings recorded during early surveys were subject to considerable inaccuracies of position.

Now a marine surveyor is confronted with an entirely different situation. He does not have to stop his vessel even to make deep soundings. He simply turns on his echo sounding machine, which sends out sound impulses, and he watches the flashes of light on a dial which indicate the return of the sound from the bottom. An accurate timing device gives the depth by measuring the elapsed time between the sending out of the sound and the return of the echo. Furthermore, he may obtain his position a hundred miles or more from land by dropping bombs overboard at regular intervals and recording the time between the explosion of the bomb and the receiving of radio flashes indicating the arrival of his sound at known positions.

These new methods have made possible the extension of our knowledge of submarine topography down to depths of a mile or even two miles below the surface of the ocean for scores, and in some areas hundreds of miles out from the coasts of the United States. The entire coast of California has been explored this way out to depths of 12,000 feet. Furthermore, these methods have shown the way to obtain future surveys of the entire ocean basins and already many echo-sounding lines have been run across the Atlantic and the Pacific.

NEW DISCOVERIES OVERTHROWING OLD IDEAS

Geologists and geographers were familiar with some of the features of the sea floors. They knew, for example, about the broad, shallow

* These submarine canyons are shown on the "Geomorphic Map of California," which is an inset on Sheet III of the Division of Mines' new "Geologic Map of California," prepared by Olaf P. Jenkins, 1938.

** Scripps Institution of Oceanography and University of Illinois.

"continental shelves" extending out from the shores towards the deep ocean basins. Also they were aware that there were a few valleys in these shelves and slopes and one finds references to these features with terms such as "submarine gulley" implying the insignificant role which was formerly applied to them. Beyond these items of knowledge the scientists delved into speculation. They assumed that the continental shelves were largely great embankments of sediment built out from the lands by the undertow of the waves. These shelves were supposed to have coarse sediment inside, such as gravel and sand, and outside the sediment was said to grow finer and finer till "the outer portion was covered by mud alone." Beyond the continental slopes the deep floor of the ocean basin was described as "—in general, monotonously level," or as "—so nearly flat that the eye would not detect its departure from planeness."

With such a picture as this it is no wonder that geologists formerly took very little interest in the oceans. But this is not the right picture. The results of the new surveys and of the investigations which several of us have been carrying on recently have shown that instead of the great banks of fine continental detritus out on the outer shelves there are extensive areas of rock bottom and much sediment as coarse or coarser than that along the coasts. For example, off California there are numerous fishing banks with covering of sand and gravel. Also, instead of a flat ocean bottom we are finding one that is decidedly irregular with less conspicuous plains than on the land surface.

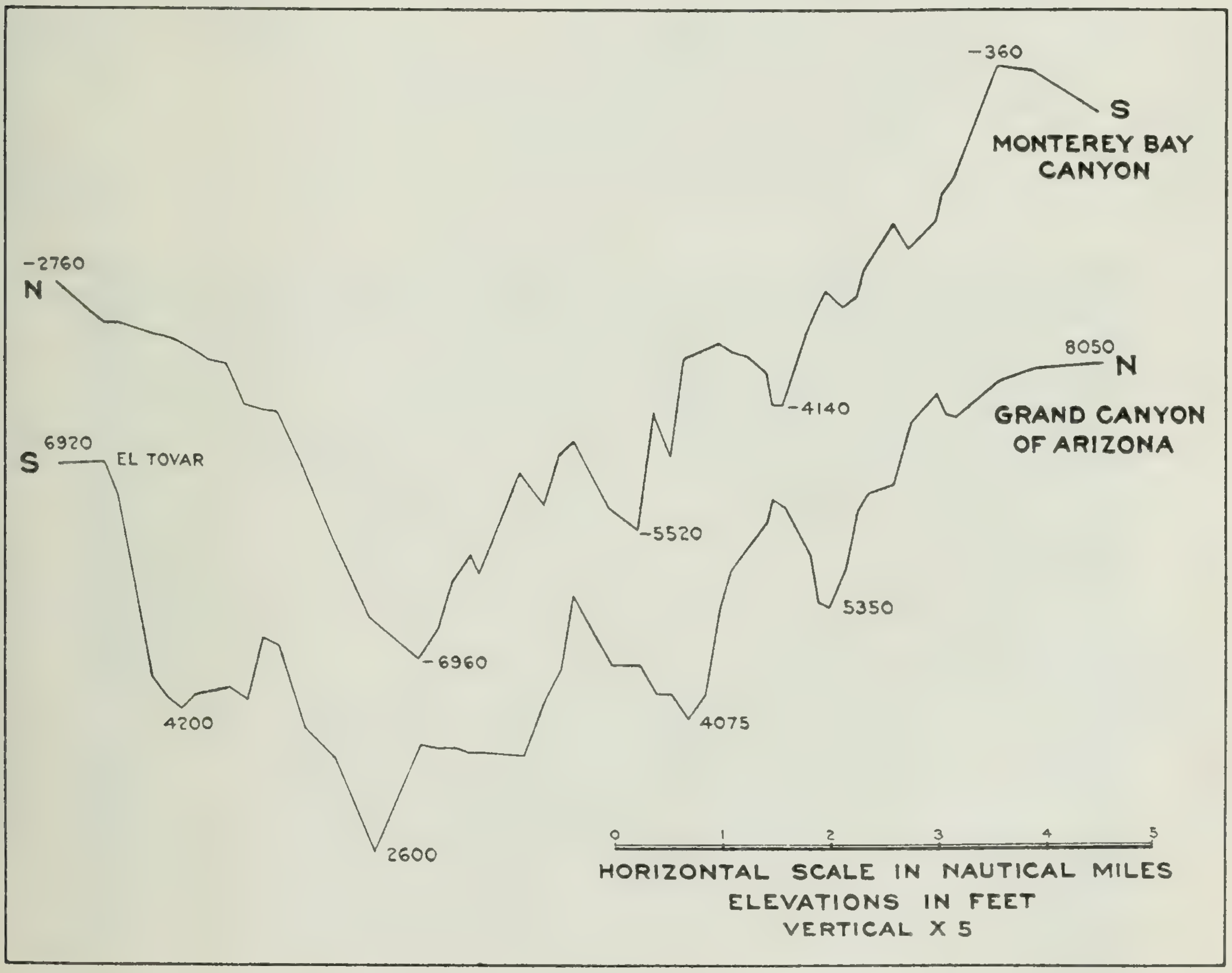


FIG. 1. Profiles showing a comparison between the Grand Canyon and a section across Monterey Submarine Canyon. The same scale and same number of observations used for the construction of each section.

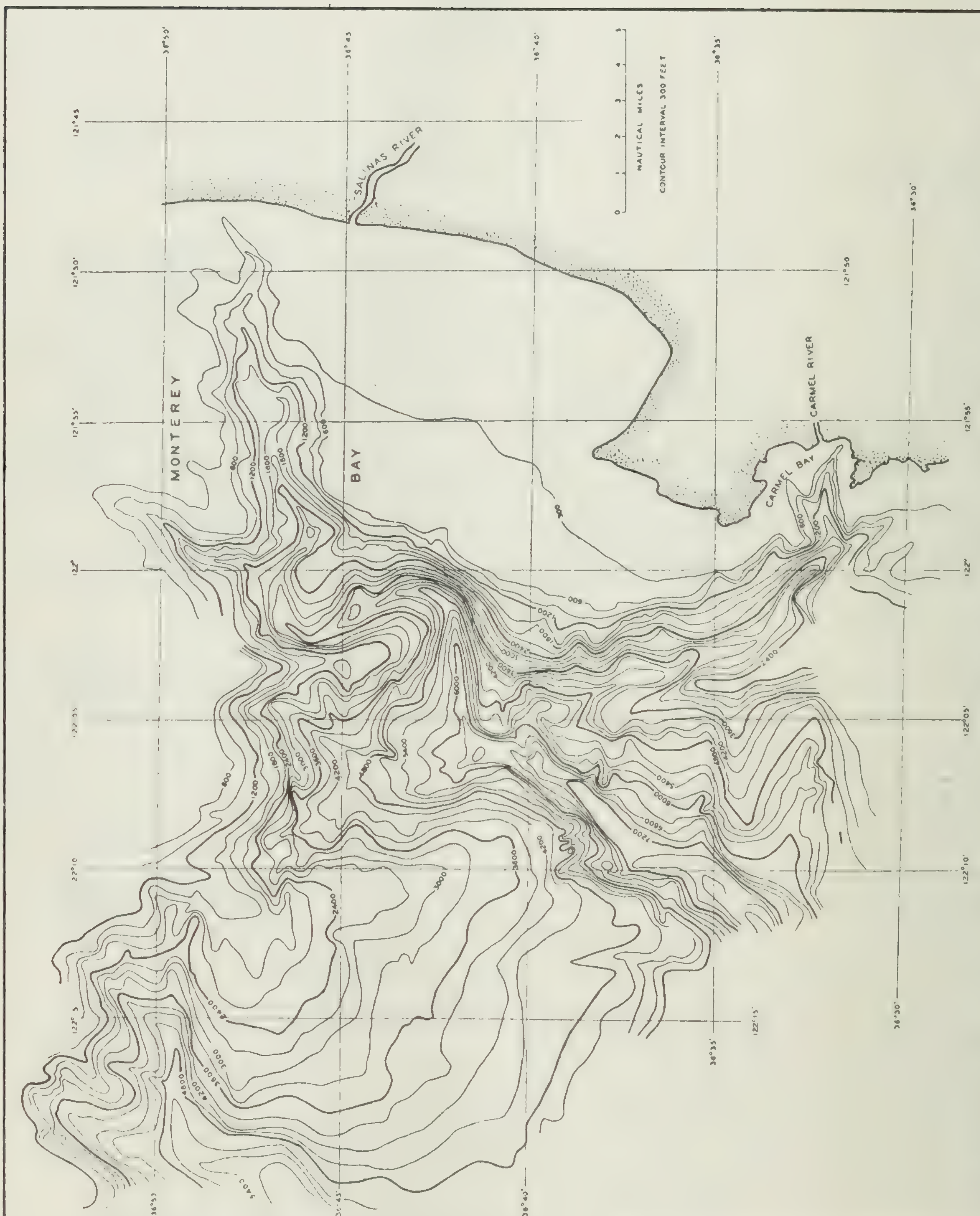


FIG. 2. Contour map of Monterey Canyon showing also the tributary coming out of Carmel Bay and joining the Monterey Canyon.

GREAT MARGINAL ESCARPMENTS

The continental slopes connecting the shelves and the deep ocean floor have been practically undescribed by scientists although one might easily have inferred that if built of great banks of sediment, as claimed by geologists, they would be relatively smooth like the submerged fronts of deltas. In contrast to deltaic foreslopes, we are finding in most places jagged irregular topography comparable to that of the greatest of land escarpments. It is probably correct to say that if we could view the world devoid of its oceans from the surface of the moon the feature which would impress us the most would be these great marine slopes from 5000 to 30,000 feet high. Including the slopes of bordering mountain ranges, which would merge with the continental slopes, a maximum declivity of 40,000 feet would be seen off parts of the Andes on the west coast of South America.

CALIFORNIA SUBMARINE CANYONS

If from an hypothetical lunar observatory we could examine these exposed continental slopes through a high-powered telescope we would see numerous great canyons cut into their upper portions. The canyons off the California coast would impress us particularly. Turning the telescope to the western slope of the Sierra Nevada we would be impressed by the remarkable similarity between the canyons of the oceanic margins and those of the land.

Coming down to the earth's surface while the ocean remained conveniently withdrawn from its basins, we could look more closely at these exposed canyons. Supposing we drove out onto Monterey Peninsula in California along the "17 mile Drive," stopped at Point Pinos, and walked north for three miles over the continental shelf. We could then look down into one of the greatest canyons on the earth's surface.

FIG. 3. A small harbor at the head of Carmel Canyon.

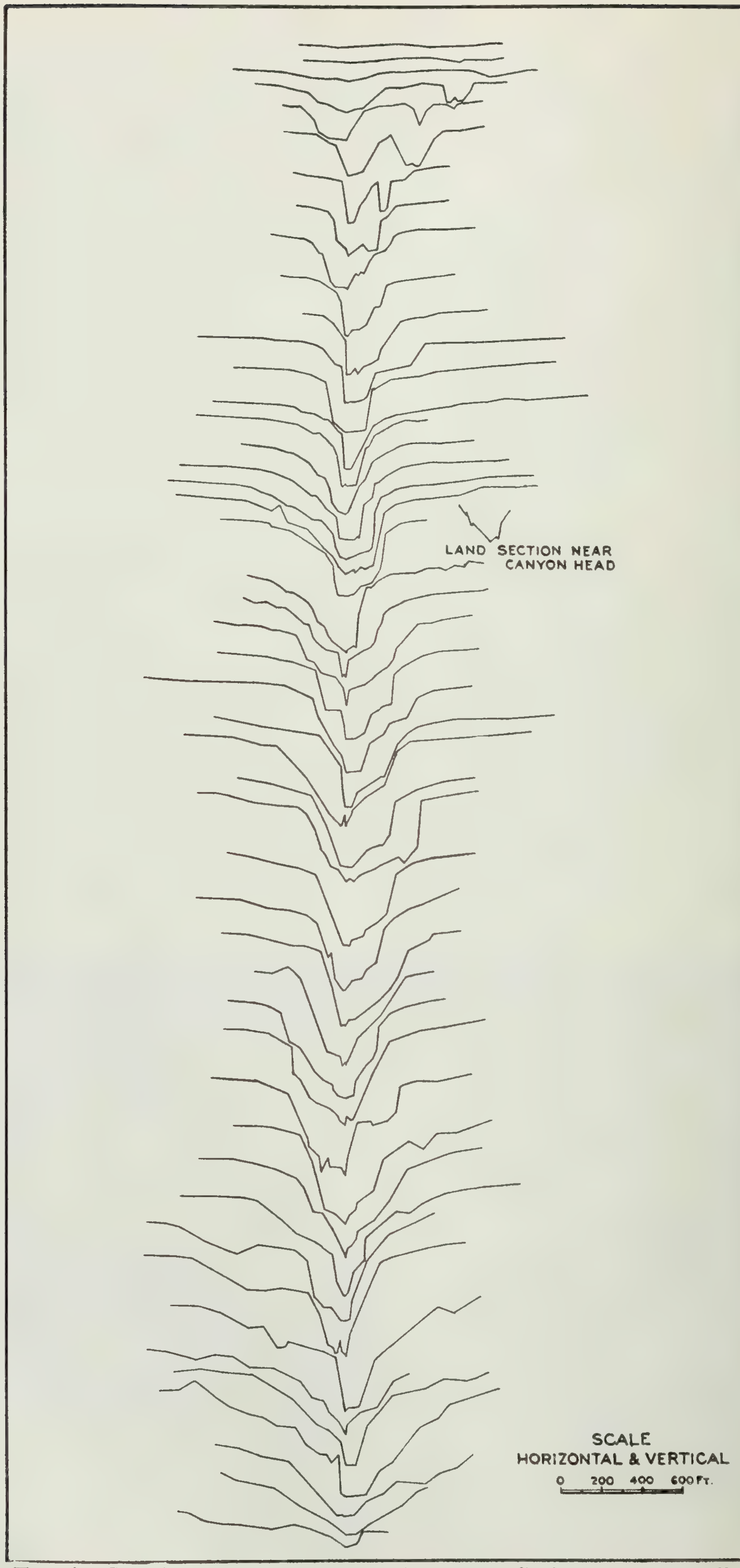


FIG. 4. Profiles made to true scale across Scripps Canyon off La Jolla, California. Note the comparison with the small land canyon.

We could see its floor 7000 feet beneath us and looking beyond we could see the other wall of the canyon rising 5000 feet. The width and vertical dimensions would compare with those of the Grand Canyon (fig. 1). Further to the left we could see a large tributary canyon winding into the main canyon and coming from the direction of Carmel Bay (fig. 2). Walking south along the brink of this tributary canyon we would find that it sent one branch so far up into Carmel Bay that it all but touched the beach at the north end of Point Lobos State Park (fig. 3).

Next, if we flew south in an aeroplane along what is now the coast of California we would pass a number of rocky canyons with a maze of tributaries coming into them. Then we would pass a zone with a gentle continental slope where only shallow valleys exist, but after rounding the corner at Point Arguello and flying over Santa Barbara we would see another series of canyons which cut the short, steep continental slopes at close intervals all the way to San Diego. We could stop appropriately at the Scripps Institution of Oceanography at La Jolla. There we could walk out over a gentle slope for half a mile and come to a stop at the edge of an abyss which would be more striking than anything we would have seen hitherto on this exposed ocean bottom. We could approach the edge cautiously and look over an almost vertical 600 foot cliff to a rocky chasm beneath, which would be so narrow we could almost throw a stone across to the platform on the other side (fig. 4).

EAST COAST CANYONS

At this juncture we might begin to wonder whether the sea bottom canyons were confined exclusively to the California coast. We could again get into our aeroplane, and this time head across country to have a look at the exposed western rim of the Atlantic. Arriving at Newport News we could fly out across the shelf to a position from which we could see the continental slope. Here again we would be greeted with the view of large canyons and as we continued northeast along the slope we could see more canyons, at first rather widely

FIG. 5. A model of canyons off the New England coast. Each of these has been cut thousands of feet below the surrounding slope.

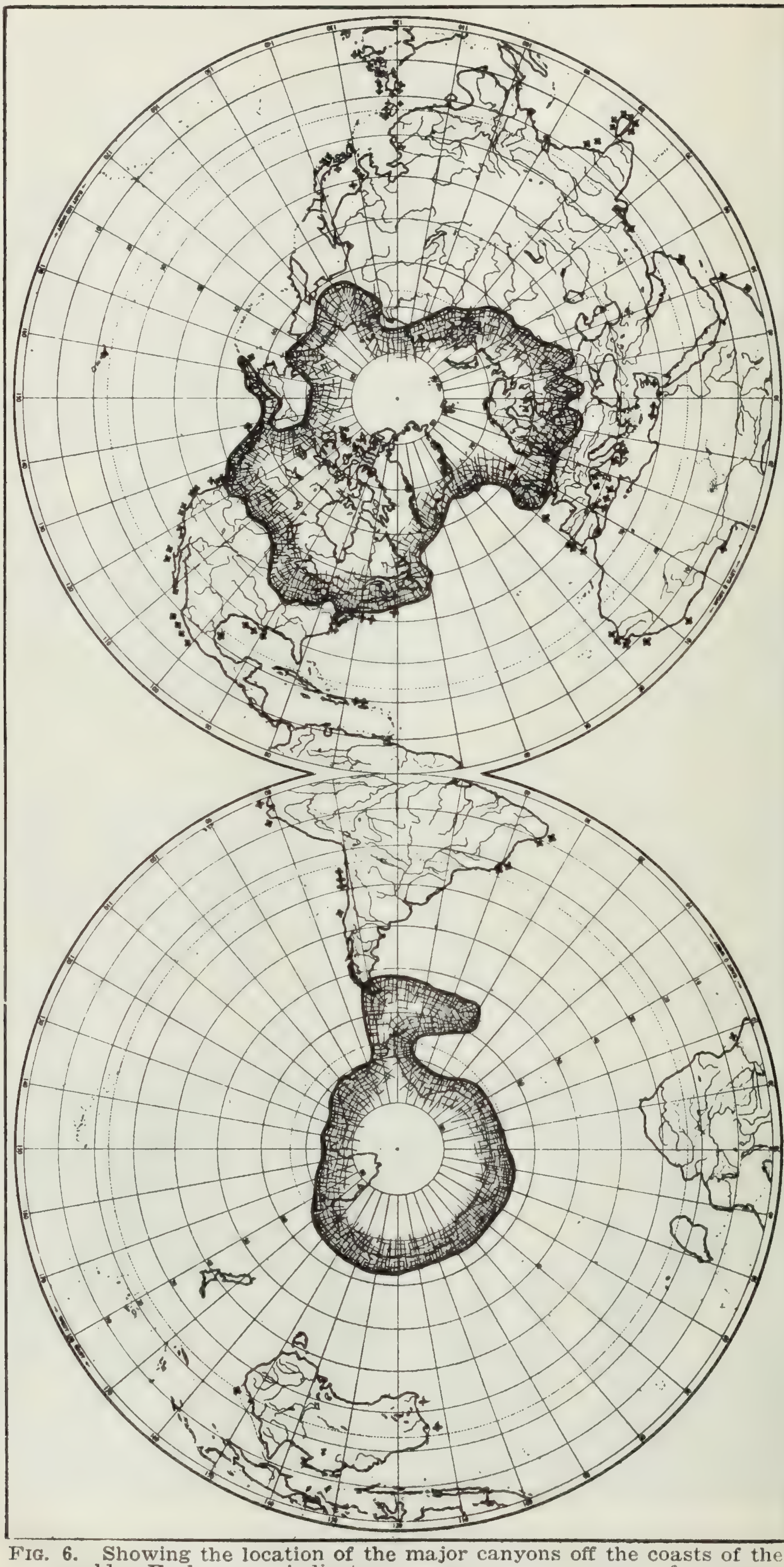


FIG. 6. Showing the location of the major canyons off the coasts of the world. Each cross indicates a canyon or a group of canyons. Shows also the hypothetical extent of the Pleistocene ice caps at the north and south poles which might account for a lowering of sea level of thousands of feet.

spaced and then coming close together till off Georges Bank (the fishing area off Cape Cod) we could find a series of canyons as closely spaced as any we had seen off the California coast. Nor would these east coast canyons appear small in comparison with those off California (fig. 5). Many of them could be found which were cut thousands of feet into the slopes and at least some of them would reveal extremely steep walls with cliffs of rock outcropping on the sides.

CANYONS OF THE OTHER COASTS

The picture which has been given above of the canyons off parts of the coasts of the United States could probably be duplicated off most of the other coasts of the world. Soundings are not as numerous off these other coasts, so that the canyons are only roughly outlined except where they come in close to the shore, and probably many have not yet been discovered. The problem which confronts us is to find an explanation for these marine canyons (fig. 6).

FIG. 7. The Yosemite Valley—a typical U-shaped valley such as is produced by ice erosion.

COMPARISON WITH LAND VALLEYS

During the past century geologists fought out the problem of whether the great valleys of the land such as the Grand Canyon were cut by streams or whether they were the result of disruption of the earth's crust. This problem was finally settled and now scientists are agreed that most of the valleys of the land have been carved by running water, although certain ones have been shaped by ice and still others are largely the result of crustal movements. There are, however, definite characteristics which show that valleys have been cut by ice, as for example, the U-shaped Yosemite Valley (fig. 7). Likewise the long straight valleys with steep walls and broad floors sometimes extending below sea level, such as Death Valley in California (fig. 8), or the Dead Sea Valley in Palestine, are known to have been formed by the sinking, or down-faulting, of blocks of the earth's crust. This faulting is a process which is still in evidence as witnessed by the occasional earthquakes. On the other hand, the winding V-shaped canyon

(fig. 9), which is the most common type of valley in mountain slopes and in the escarpments of the edge of great plateaus is unquestionably the result of the work of running water. The submarine canyons clearly resemble this last type of land valley.

FIG. 8. A view of Death Valley showing the broad floor which characterizes fault valleys.

FIG. 9. A typical V-shaped valley such as is produced by stream erosion.

PERPLEXING SITUATION

Since these ocean bottom canyons are the counterparts of the river-cut land canyons, it is natural to suppose that they must also have been cut by rivers. This idea, however, cannot be accepted without realizing some of the difficulties with which it is confronted. Rivers lose their power where they enter the ocean, so that in order to excavate canyons below the present sea level, they must have flowed over continental margins which stood relatively much higher than they do now. Furthermore, this change of level of many thousands of feet which brought the canyons into their present submerged position would appear to have been a comparatively recent occurrence since the canyons are not filled to any extent with the sediment which is being constantly washed towards them from the lands. Also, the formations off the California coast through which these canyons have been cut are known to be among the most recent of geological history. The coasts inside most of these California submarine canyons, however, are relatively straight, quite different from the great irregularities which would develop as a result of the penetration of the sea into the valleys of a subsiding coast. Finally, the canyons are found most profusely off coasts such as California, where there is much evidence of a rising of the land in relation to the sea rather than of sinking.

SUBMARINE CURRENT ALTERNATIVE

Some geologists, appreciating the difficulties accompanying the above explanation of the origin of submarine canyons, have looked around for other explanations. Alternatives have been proposed mostly by men who had not had the opportunity to observe all of the recent accumulation of data concerning the character of the canyons. A few scientists suggested that submarine faulting had been the cause, but the shapes and trends of the canyons are so obviously unlike land fault valleys that this idea is not taken seriously at the present time. A more likely possibility comes from the suggestion that powerful submarine currents have excavated the canyons. The currents have been variously attributed to the subsurface return of the water driven into bays by violent storms; to the moving down the continental slopes of heavy mud-laden currents; and to the sub-surface counter current set up by outward moving surface water at the mouth of a river.

OBJECTIONS TO CURRENT EXCAVATION

It happens that submarine currents have not been studied very much as yet, but such information as is now available is emphatically in opposition to the idea that the enormous submarine canyons may have been caused by anything of this nature. Observations of the currents in several of the canyons have shown that they are very feeble or non-existent. The collection of water samples from the canyons shows that the dynamics of the situation would make strong currents highly improbable. Furthermore, ocean currents commonly move most vigorously along the shores and yet practically all of the canyons extend out almost at right angles to the coast. Finally, currents are known to have a scooping action on the bottom leaving large, oval depressions and the soundings have not revealed such

features on the bottom of the canyons. Certainly unless more information can be obtained in favor of currents we must discard this idea as the cause of these gigantic marine features.

MUD FLOWS KEEPING THE CANYONS OPEN

Since currents do not promise to be a solution to the problem of explaining the canyons, we ought to see whether the objections confronted by the river erosion hypothesis are insurmountable. In the first place much of the difficulty hinges on the implications of recent submergence. To be sure the rocks on the canyon walls are young enough in some cases to suggest that they were cut during the Quaternary or within the last million years (which is fairly recent in a geological sense), but the unfilled condition of the canyons may not mean that they are much less than a million years old provided that the canyons have been kept open by some process. As has been mentioned, mud is being deposited on the canyon bottoms. If we take the same sort of saturated mud and place it in a trough and give the trough sufficient slope, the mud will flow out; and the greater the accumulation of the mud the less inclination will be necessary to produce that flow. The canyons with their rocky sides represent a trough and their steep outward slope provides the gradient for this flow.

GREAT CHANGES OFF THE JAPANESE COAST

The Japanese earthquake of 1923 which destroyed most of Tokyo and Yokohama was accompanied by a phenomenon which was unique in the annals of the sea. A re-survey of Sagami Bay, which was adjacent to the zone of destruction, showed that there had been enormous changes of depth with deepening that may have been as much as 1,000 feet. This deepening was so much greater than any observed change of elevation due to faulting during an earthquake on land that it caused much surprise. It happens, however, that the change was in a large submarine canyon. It is easy to understand how an accumulation of mud, probably supplemented to a great extent by volcanic ash and even lava flows, could have been given sufficient impetus during the earthquake to start a mud flow down the canyon floor and out towards the great Tuscarora deep. The Grand Banks earthquake off eastern Canada produced a similar effect, only in this case the depth changes could not be determined, but the breaking of cables over a wide area was clearly the result of great submarine mudflows. Cable companies are frequently troubled by this process and in many cases the sliding takes place in submarine canyons.

COAST STRAIGHTENED SINCE SUBMERGENCE

If the canyons have been submerged for a considerable length of time and have been kept open by mudflows, the straightness of the coasts inside is no longer hard to understand. We know that waves and currents are quite capable of straightening coasts by cutting away headlands and building bars across the mouths of bays. Furthermore, the straight coast of California shows upon examination that it has blocked and partially filled remnants of estuaries, some of them opposite the submarine canyons.

CHANGE OF SEA LEVEL

The chief remaining difficulty with the river valley explanation is that the canyons are so universal, being found both off stable and unstable coasts and even off coasts where considerable uplift is thought to have occurred. It is not easy to develop a satisfactory explanation for this difficulty, but there may be one way out of the dilemma. Crustal movements are found to be different in different places, whereas changes of sea level produce worldwide results. Therefore, is it not a sea level change with which we are dealing? If the ocean had been lowered several thousand feet the rivers of the lands would have flowed out over the continental shelves and would have cascaded down the steep continental slopes beyond, cutting rapidly into the relatively soft sediments of this outer zone. Then a rise in the sea level would have drowned these canyons. Nor would it be necessary that the sea level be lowered to the extent of the greatest depths of the canyons because the removal of the weight of water from the ocean would have caused a bulging of the sea floor along the oceanic margins. Also the submergence of canyons along many coasts due to crustal movements may have been going on for many millions of years and the lowering of sea level would have allowed the land streams to flow into the upper end of these canyons, connecting them with the present coast or with the outer edge of the present continental shelf.

A CAUSE FOR SEA LEVEL LOWERING

A still more difficult problem is to explain the lowering of sea level which seems necessary. We know that beyond all reasonable doubt the interior of the earth is solid, so that water could not be drawn into the earth and then returned. The ocean bottom might sink, pulling the water down with it and then rise bringing up the sea level, but the magnitude of such a movement would have to be enormous. For example, if a million square miles of the ocean floor should sink 6,000 feet (which would be comparable to some of the greatest movements which we know have occurred on the lands within a similar period) the sea level would be changed only 34 feet. Furthermore, the movement would have had to have been reversible and we know of no reversible movement of such magnitude in anything like such a short time in earth history. To make matters worse the sinking of the entire ocean would have drowned the oceanic islands and we find that the islands show evidence of having been effected by this sea level change, particularly the coral islands with their submerged reefs.

GLACIERS AND SEA LEVEL CHANGES

It seems not unlikely that the lowering was the result of an actual extraction of water from the ocean. The air could hold only the equivalent of a few feet of ocean water in addition to its present load. However, the ocean could be piled up on the land in the form of ice. It has been suggested that during the glacial period the great continental glaciers contained enough ice to be the equivalent of about 300 feet of ocean water. Such estimates have been made with considerable conservatism. There were several glacial epochs and it is

possible that the glaciers during one or more of the early epochs may have been much more extensive than commonly estimated and also much thicker. The ice, for example, may have covered the entire polar sea as a great ice dome with a thickness of four miles or more. There seems to be no particular reason for doubting such a possibility. If the ice covered the area indicated in figure 6 and had an average thickness of four miles it would have lowered the sea level 3,000 feet and would have thus allowed the cutting of most of the known canyons of the continental slopes. It is even possible that the ice sheets were still larger and thicker so that a lowering of as much as 6,000 feet may have occurred. There are canyons, however, that go to still greater depths. The bulging at the oceanic margins, referred to previously, which would accompany a lowering of sea level may account for those deep canyons. However, much work remains to be done before a thoroughly satisfactory explanation can be given.

A FERTILE FIELD FOR RESEARCH

Since we have been spending millions of dollars every year in trying to find out about the distant stars which under the highest powered telescopes are mere pin points of light, it would seem to be time that we started to investigate some of the truly startling features of the virtually unknown territory of our own planet. Here is a field the exploration of which holds remarkable possibilities. Furthermore, it is not going to be very long before we can actually go down and move around over the canyons and mountains of the ocean bottom, seeing them with our own eyes. Great bathospheres with arms for propulsion on the bottom are already being constructed by diving companies for the purpose of regaining treasure from the bottom. Soon we may hope to have a look at some of the remarkable scenery of the ocean floor. There is no place in the world better fitted for such exploration than off the California coast.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of California Journal of Mines and Geology.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

8—62700

THE MOUNTAIN COPPER COMPANY, LTD. CYANIDE TREATMENT OF GOSSAN

By Chas. Volney Averill, Mining Engineer

Introduction.

This division published an article[1] in 1931 describing cyanide treatment of gossan as then practiced by The Mountain Copper Company, Ltd. The block of 550,000 tons of ore described in that article has been mined. It was comparatively of good grade, easy to mine, and easy to treat. However the plant has been kept in continuous operation since 1931 at an average capacity of roughly 600 tons per day until recent additions were made. Development of additional ore to make this possible has introduced many problems, one of which was an increase of natural clay in the ore, which caused trouble from channeling in sand-percolation tanks. To solve this problem, the plant has recently been remodeled at a cost of approximately $100,000 to provide separate treatment for sand and slime. Capacity has reached nearly 750 tons per day and may be increased. Recovery of gold has been greatly improved, being now over 95 per cent.

Acknowledgments.

Wm. F. Kett, 351 California Street, San Francisco, is general manager of the company, and L. T. Kett is assistant manager. At Iron Mountain (post-office address: Matheson) J. G. Huseby is general superintendent and D. L. King is mill superintendent. The writer is indebted to these officials for the information on which this article is based.

Photograph 1. Cyanide plant, The Mountain Copper Company, Ltd.

[1] Averill, C. V., The Mountain Copper Company, Ltd., Cyanide Treatment of Gossan, California State Mineralogist's Report XXVII, pp. 129-138, 1931.

History.

The property is one of the oldest on the Shasta County copper belt. It was discovered in the early sixties; and The Mountain Copper Company, Ltd., of London, England, purchased it on January 1, 1897. In addition to being at one time among the largest copper producers of the world, the company has produced sulphuric acid, fertilizers, gas purifier and bluestone. A smelter (now dismantled) was operated at Keswick; and there is another at Martinez. In addition to the cyanide plant at Iron Mountain, the company operates the Hornet mine, a producer of pyrite, and the Big Canyon gold mine near Shingle Springs, El Dorado County. The location of the Shasta County property is in Sec. 34, 35, T. 33 N., R. 6 W., M. D. M., 17 miles northwest of Redding. A railroad station on the main north-south line of the Southern Pacific at Matheson serves the property.

The ore formerly treated was a typical reddish-brown gossan, largely porous oxides of iron remaining from the leaching by surface waters of a body of iron and copper sulphides. The weight was about 100 pounds per cubic foot, and about 0.4% copper remained in it. Most of the ore now being mined has much the same appearance, but it has been derived from original sulphide ore in which the country rock was not so completely replaced by sulphides. Hence it is higher in silica and lower in gold and copper content. Present copper content after oxidation and leaching by surface waters is only 0.2%. Natural (primary) slime content goes nearly as high as 40% in some blocks. There is a small content of mercury, which appears in the precipitate, and a little arsenic.

Exhaustive tests on the amenability of this ore to cyanide treatment, made before the original plant was built, were described in some detail in the earlier article, and these descriptions are not repeated here.

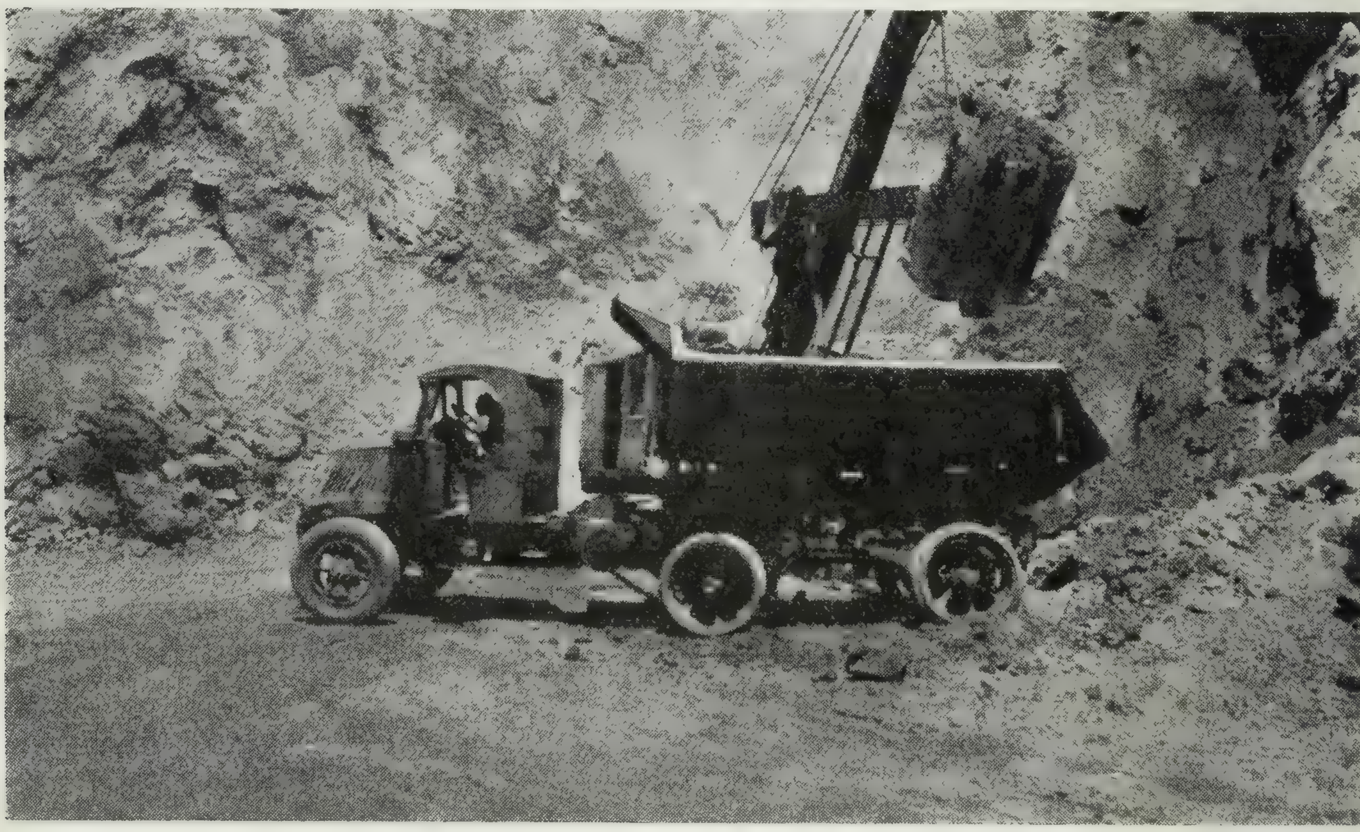
A few alterations were made in the plant prior to the recent addition of slime treatment. Two additional tanks were added for sand-percolation, but these have now been converted to Dorr agitators, and 10 tanks are left for sand-percolation as before. Secondary crushing in the original plant was done with rolls. In 1931, the same hammer-mill that is now in use was installed to take oversize from the vibrating screen. It reduced the ore from 1-inch to $\frac{1}{4}$-inch in size, and was in open circuit with the sand-percolation tanks. To keep the impact-side of the hammer-mill clear of lumps of clay, a revolving breaker drum was installed. This was built like an ordinary roll with a replaceable shell of tool steel. At the present time cyanide solution is fed to the hammer-mill and the revolving breaker drum is no longer needed.

Mining.

Since 1931, heavier equipment has been put in service in the quarry. The main reason for this is that for several years an average of three tons of overburden has been moved to each ton of ore mined. Hence mining costs have increased. The various benches of the quarry now extend from an elevation of 2600 ft. above sea level to about 3300 ft., or for a vertical height of roughly 700 ft. Two shifts of men work in the quarry. Overburden is stripped and some ore is hauled on the day shift, and ore is mined at night.

Mining equipment now includes the following power shovels: $\frac{3}{4}$-cu. yd. electric, No. 1030 Bucyrus Erie; No. 37B Bucyrus Erie equipped with a $1\frac{3}{4}$-yd. bucket and driven by a D13000 Caterpillar diesel engine; No. 101 Lima with a $1\frac{1}{4}$-yd. bucket and driven by a Wisconsin gasoline engine; Model 6 Northwest with $1\frac{1}{2}$-yd. bucket and driven by a Northwest oil engine; $\frac{1}{4}$-yd. roustabout shovel, which is not used much.

Trucks include four 11-cu. yd. semitrailer AC Mack Bulldog trucks, which carry 16 to 18 tons to a load. They have 40-inch by 16-inch solid tires on both drive-wheels and trailer-wheels, and are equipped with F8 Gar Wood heavy-duty hoists. There are also six 4-cu. yd. AC Mack Bulldog trucks with 18-inch by 24-inch pneumatic tires on drive-wheels. All trucks have chain-drive. A model 50 Caterpiller diesel bulldozer is in use, and an RD8 diesel angledozer. An AC Mack truck is used as a sprinkler and two AB Mack trucks for hauling fuel-oil. A road-grader is provided also.



PHOTOGRAPH 2. Truck and power shovel in gossan quarry.

At present a J12 Le Tourneau Carryall of 14-cu. yd. capacity is being rented; also a three-tooth heavy-duty rooter. The Carryall is drawn by a D8 Caterpillar diesel tractor. Work with this outfit is new, and consists of mining marginal ore at the top of the quarry. Ore is hauled to the edge of the bench by the Carryall, and is then pushed over the edge with a bulldozer. It drops to a lower bench, where it is picked up by a power shovel.

As the method of mining is undergoing changes and a description of present methods probably would soon be out of date, no further details of mining methods or mining costs are given here.

Crushing and classification.

Ore is dumped by trucks on a grizzley with $10\frac{1}{2}$-inch openings set over two storage bunkers each 38 ft. by 16 ft. by 20 ft. high. Beneath

PHOTOGRAPH 3. Carryall and tractor working on top bench of gossan quarry.

each bunker is a Link Belt reciprocating feeder, three-chute type, feeding Stephens Adamson pan-conveyors. The feeders are regulated by changing the throw of eccentrics. Each is powered by a $7\frac{1}{2}$-h.p. motor. Each pan-conveyor is powered by a 5-h.p. motor. The one under No. 1 bunker is 40 inches wide and travels at 8 ft. per minute, the one under No. 2 bunker is 32 inches wide and travels at 30 ft. per minute. Each has a capacity of 100 tons per hour, but they are not used at maximum capacity.

Pan-conveyors are on either side of a grizzley over the crusher, and both discharge on this grizzley. Oversize is crushed in a 15-inch by 36-inch Universal crusher of a modified Blake type, driven by a 50-h.p. motor through a 10-rope Allis Chalmers V-belt drive. Undersize from the grizzley and crusher product join on a 30-inch conveyor, 36 ft. long between pulley-centers. This is called No. 2 conveyor. It travels at 260 ft. per minute and is driven by a 5-h.p. gear-motor. Suspended over it to pick up tramp-iron is a Dings bipolar, high-intensity magnet energized by 1 kw. direct current at 110 volts furnished by a motor-generator set. No. 2 conveyor feeds directly into the feed-chute of a Jeffrey B3, 24-inch by 36-inch impact pulverizer (hammer-mill). This is a standard rotor-type with a rotor carrying 39 double-ended hammers weighing 12 lb. each. It is driven by a 75-h.p. variable-speed, wound-rotor motor through a 10-rope V-belt drive. Maximum speed of the hammer-mill rotor is 1400 rpm. Hammers are made of a high-silica cast-iron of high tensile strength and both wearing-ends are chilled. This application of the hammer-mill is unique, and is made possible by the friability of the ore. Ore is reduced from $2\frac{1}{2}$-inch size to $\frac{1}{2}$-inch size with a minimum of slimes at a cost of \$0.006 per ton. To the hammer-mill is added enough cyanide solution to prevent packing in the machine. This amounts to half a ton of solution to one of ore.

The hammer-mill discharges into a custom-built flight-pug conveyor. The simplex flight section is 6 ft. long and contains a screw 16 inches in diameter with 9 turns in the 6 ft. Following this is a duplex pug section containing two rotating shafts, on which are mounted 12 paddles to each shaft. The shafts are turned in opposite directions at 53 rpm. by a 7½-h.p. gear-motor with shear-pin coupling. The purpose is to break up or digest lumps of clay.

Discharge from the pug-section goes directly to the feed-well of a new turret-type Dorr DSFB bowl classifier for separation of sand from slime. It consists of an inclined (1½ inches to 1 ft.) rake compartment, 33 ft. 4 inches long by 9 ft. wide, containing reciprocating rakes. At the lower end is a circular bowl, 11 ft, in diameter, containing rotating rakes. The bottom of the bowl opens into the rectangular rake compartment. This arrangement provides a double separation of sand and slime. Feed goes into a partially submerged cylinder in the center of the bowl, the sand falls to the bottom and is discharged into the rectangular compartment by the rotating rakes in the bowl. Slime overflows at the periphery of the bowl. Sand is picked up by the reciprocating rakes, and is gradually raked up the incline, where it passes under three different sprays of cyanide solution from perforated pipes extending across this compartment. The last of the slime is thus washed back to enter the bottom of the bowl.

Bowl rakes are normally driven at 4 rpm. by a Reeves variable-speed motor drive-unit of 1½ h. p. Reciprocating rakes are driven at 12 to 24 strokes per minute total for the two rakes by a chain and sprocket drive and 7½-h.p. Reeves No. 2 variable-speed transmission. The bowl is equipped with a 'critical size control' to prevent a certain size of particle from accumulating in the central column of the bowl. It is an air-lift supplied with 80 cfm. of air at 1 lb. per sq. inch pressure by a Roots Connersville blower. It has been found unnecessary and has been disconnected.

Sand treatment.

Sand is well drained of moisture in the upper part of the inclined rake compartment of the classifier, and is discharged by the rakes to the 'C' conveyor. This is a 20-inch belt conveyor, 35 ft. long between pulley-centers, driven at 360 ft. per minute by a 90-rpm. Westinghouse-Nuttall gear-motor of 3-h.p. It is inclined at 18° above horizontal and discharges to No. 3 conveyor set at right angle to it. No 3 conveyor is a 20-inch belt, 100 ft. long between pulley centers, set at an angle of about 10° from horizontal. It is driven at 280 ft. per minute by a 19 to 1 Pacific [2] gear reducer directly connected to a 10-h.p., 1800-rpm., General Electric motor. No. 3 conveyor discharges over a 4 ft. by 5 ft. Link Belt vibrating screen of the counterweight type. Weights in the drive-pulley cause the vibration. This is driven through an endless belt by a 5-h.p. motor with a speed of 1800 rpm. Screen cloth is Tyrod with slots ½-inch wide by about 4 inches long. Oversize is returned to No. 2 conveyor feeding the hammer-mill by a 20-inch conveyor, 125 ft. long between pulley-centers. It is driven at 240 ft. per minute by a 5-h.p Pacific G. E. gear-motor. Circulating load is usually 5 tons to 10 tons per hour depending on the friability of the ore and the clearances in the hammer-mill.

[2] Pacific Gear Works, San Francisco.

Screen undersize is conveyed directly to sand-percolation tanks by a 20-inch conveyor, about 350 ft. long between pulley-centers. It is driven by a 20-h.p. G. E. induction motor through an 18 to 1 speed reducer. This is connected to the drive pulley by a chain and sprocket; also by gears to a tandem-drive pulley. The conveyor belt passes through a Jeffrey self-propelled tripper, which runs lengthwise over the row of 10 tanks used for sand-percolation. These are cylindrical wood-stave tanks, 25 ft. 8 inches inside diameter, with 12-ft. staves. They are arranged in units of five each, one unit handled by the day shift, the other by the night shift. For charging, the tripper is run back and forth over a tank, and the gossan is spread in 3-ft. layers.

Strong mill solution is added as the tank is being charged by a spray on the tripper. This is adjusted so as to keep the belt washed clean of fine sand. Enough solution is thus added so that leaching can start immediately as soon as the tank is full of ore. With the slime removed, such care in filling these tanks with sand as was formerly used is no longer necessary, and only the last 3 ft. of fill is spread by hand.

Of the five tanks in a unit, one is always being filled with ore and a second is discharging tailing. Filter bottoms of these tanks consist of cocoanut matting covered with 10-ounce canvas and 2-inch by 2-inch cleats, six inches apart. The bottoms are washed and cleaned once every six weeks by hosing with water. The leaching cycle includes 72 hours of mill solution ($1\frac{1}{2}$ lb. KCN and 0.4 lb. CaO per ton by titration) at the rate of six tons per hour and 24 hours of mill barren solution (0.8 lb. KCN and 0.4 CaO per ton) at the rate of six tons per hour. At the conclusion of 96 hours of leaching the tank is allowed to drain for discharge of tailing. No water wash is used. Tailing is discharged at about 11% moisture. Four holes, 16 inches square, spaced between the sides of the tank and the center, are provided for discharging tailing. Two conveyor belts run under these, discharging to a cross-belt, which stacks the tailing. Three men discharge a 245-ton tank and clean the bottom ready for the next charge in an 8-hour shift. Four safety ropes hang in the tank for protection during this part of the operation. The roof over the conveyor covers about two-thirds of the tank; and for rainy weather canvas curtains are provided to cover the balance and keep the men dry.

All effluent solutions from the sand circuit run by gravity to a common sump, from which they are pumped to gold solution storage by a 10-h.p., 3500-rpm., Pennsylvania[3] motor-pump, a single-stage centrifugal. All mill solution goes to sand-percolation by gravity. To simplify the accompanying flow-sheet, the 10 tanks for sand-percolation are represented by the two tanks marked 'mill solution sand treatment' and the tank marked 'barren solution sand treatment.' While sand-treatment is a batch process, of the 10 tanks in use some are always undergoing solution treatment as shown. This arrangement results in considerable clarification of all solutions, which thus pass through a sand-tank before entering the gold-solution tank. Main solution lines in this department are 3-inch and 4-inch pipes.

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[3] Pennsylvania Pump & Compressor Co., Easton, Pa., or o/o The Merrill Co., Engineers, 343 Sansome St., San Francisco.

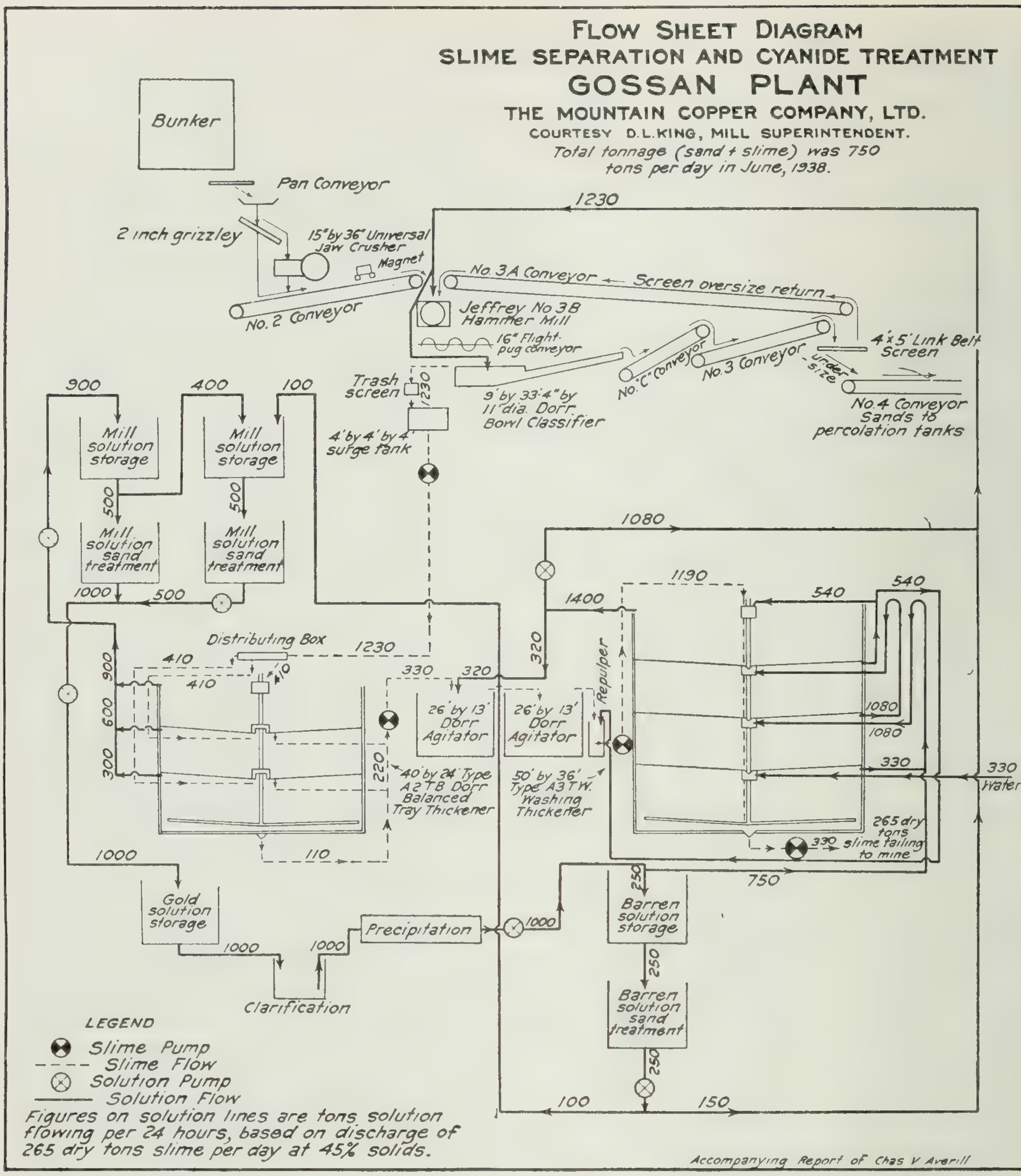
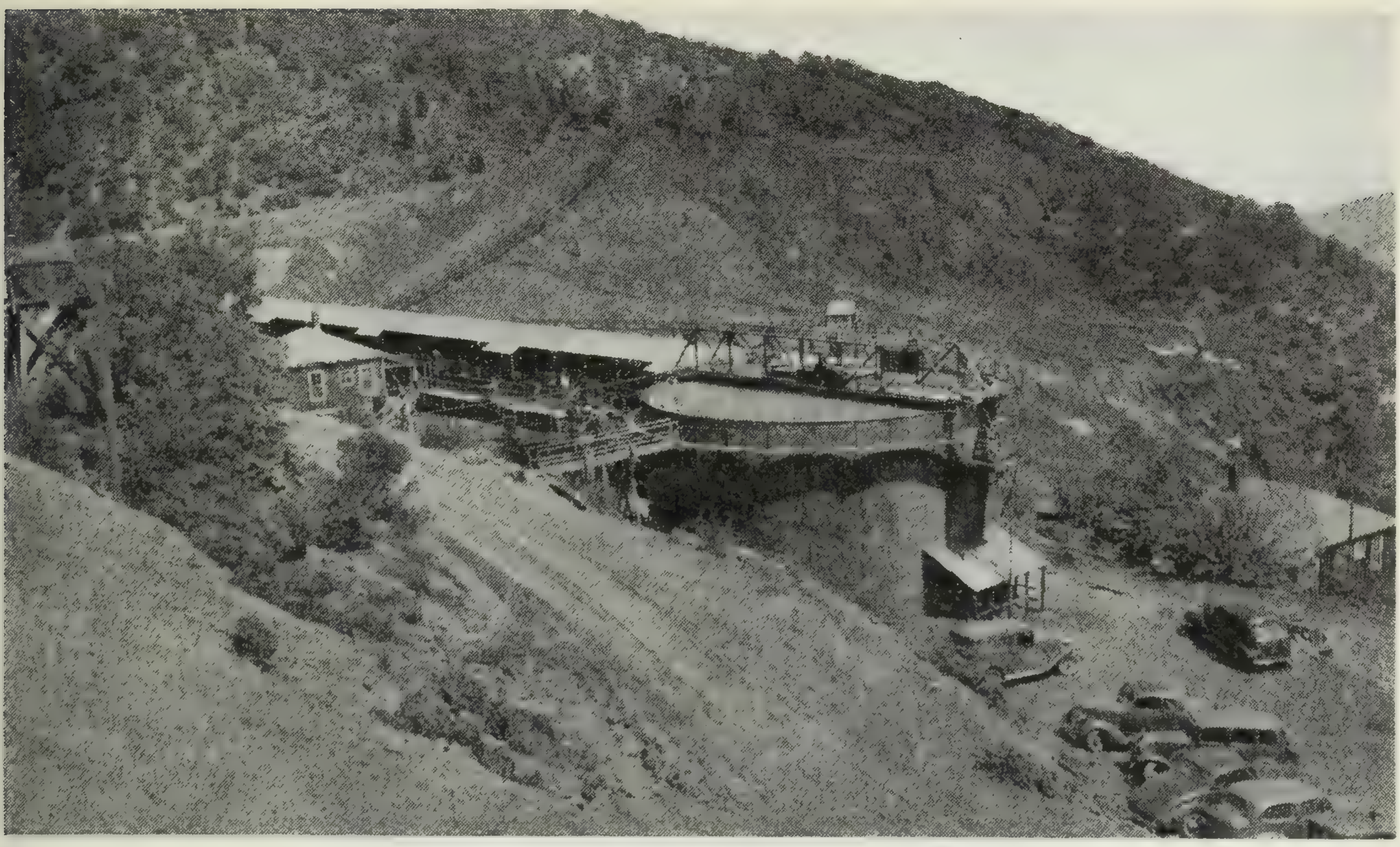


FIG. 1. Flow sheet diagram.

Slime treatment, general.

Slime overflowing the bowl of the classifier goes to a Dorr balanced tray thickener with two trays or three compartments. These compartments are arranged in parallel, that is the feed from the bowl is split into three equal parts, and one part enters each compartment. Thickened underflow from all three compartments joins in the central part of the thickener, and flows to two Dorr agitators. In the pulp leaving the agitators, most of the gold is in solution and the solids are nearly barren. The valuable solution is next displaced by barren solution and water in the four compartments of the three-tray washing thickener, from which the slime-tailing is then discharged. The change of solution causes some additional extraction of gold. In the statement of these extractions that follows, all percentages refer back to the total gold in the original slime as 100%. In crushing and classification 65% of the extraction is made, in the primary thickener and the agitators 25 %, and in the washing thickener 5%—total 95%.



PHOTOGRAPH 4. Washing thickener, 50 feet in diameter.

Counter-current decantation, general.

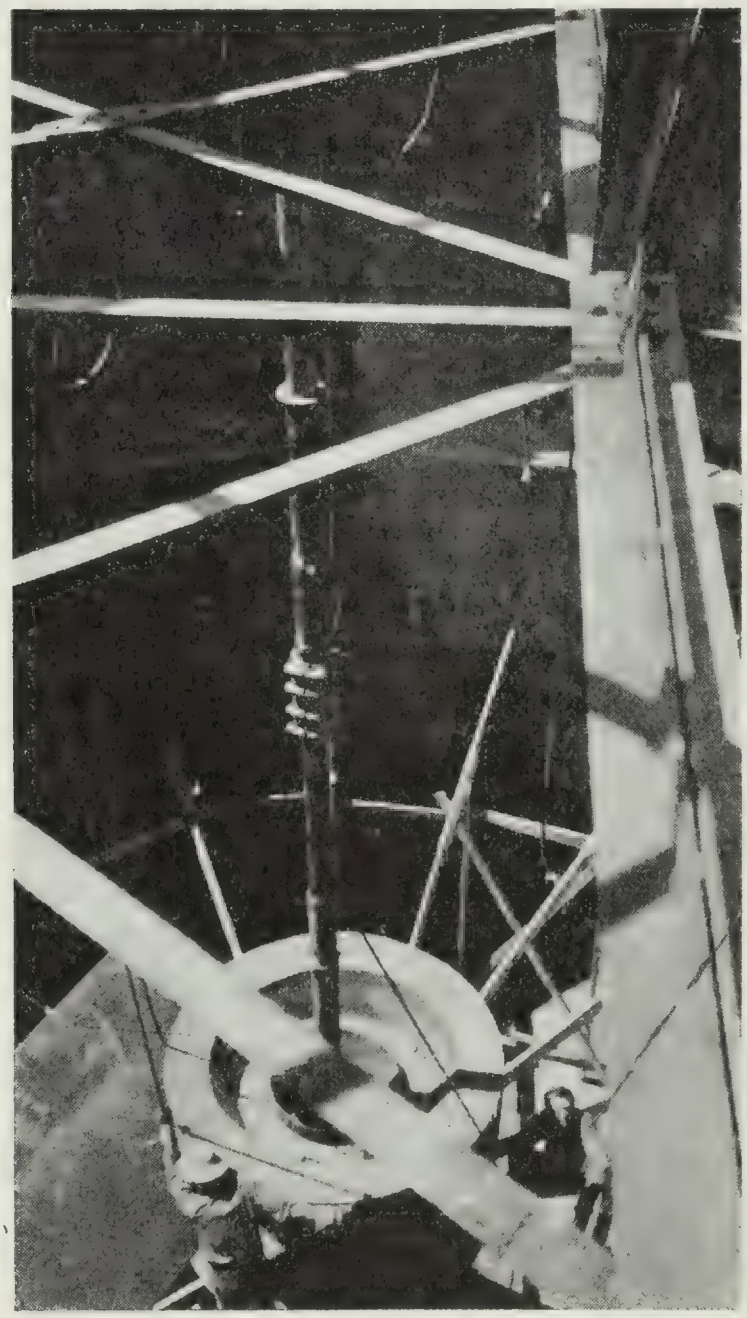
Chemical industries have for many years used decantation to separate a valuable liquid from a mixture of it with a finely divided solid. The earliest method was simply to allow the mixture to settle in a tank, then to decant the clear liquid at the top. Water or other solvent of low value was then added to the tank and the solid was again allowed to settle. The clear liquid at the top was again drawn off and saved. After four or five such steps, the liquid remaining in the settled solid contained little of value. The amount contained is easily calculated if the weight and value of the original liquid is known; also the weight of the liquid finally discarded with the solid. This is described in more detail in a pamphlet issued by The Dorr Company, Inc.[4] This batch-method consumed much time and much labor.

For some years a continuous process of this kind has been used in cyanide mills with about four separate Dorr thickeners. These are settling tanks with a rake-system in the bottom revolving very slowly to discharge the settled solid at the center of the bottom. The gold-solution mixed with the slime enters the first tank of the series, while water enters the fourth or last tank of the series, from which also tailing is discharged to waste. Clear liquid from the last tank overflows to the third. Clear liquid from the third overflows to the second, and so on. The thickened pulp from the underflow of the first tank is raised by a pump and is fed to the center of the top of the second tank, and so on through the series, the flow of thickened pulp being in the opposite direction to that of the wash-solution. Diaphragm pumps are used for handling the thickened underflow. They have an adjustable stroke so that the amount of underflow can be regulated. Between any two tanks of the series, valuable solution can be drawn

[4] The Dorr Company, Inc., Engineers, 570 Lexington Ave., New York, N. Y. Bull. 3141. Continuous counter-current decantation in cyaniding.

off to storage, and barren solution substituted as the solution-feed to the next tank.

In the Dorr[5] washing thickener, all of this is accomplished in a single tall tank separated into four or five compartments by three or four trays. Trays are placed in a horizontal position but each has the shape of a flat inverted cone, sloping downward from the outside of the tank toward the center. This arrangement introduces savings in foundation construction, in space-requirements, and in power. The washing thickener of The Mountain Copper Company, Ltd., is a complete counter-current decantation system with a connected load of only five horsepower.



PHOTOGRAPH 5. Part of tray-seal being installed in washing thickener.
(Photo by D. L. King)

The thickener is of the three-tray or four-compartment type. A central shaft runs down through the entire depth of the tank, carrying four rake systems, one for each compartment; also part of a sealing device for each compartment. For this seal at each tray an inverted cup attached to the shaft engages, with some clearance, a cup-like device attached to the tray. Thickened pulp must pass through the

[5] See also Bull. No. 3071, The Dorr Washing Thickener, The Dorr Company, Inc., Engineers, 570 Lexington Ave., New York, N. Y.

annular space between these cups, and the direction of flow is upward for a few inches. As the thickened pulp passes this seal and starts downward, it meets the flow of solution supplied by a pipe from outside of the tank to the lower compartment. Clearances in all seals as well as clearances between all rakes and their respective trays can be changed by raising the central shaft with a hand-wheel.

Operating details.

The condition of fluid-balance or hydrostatics existing in one of these thickeners is interesting. The central portion of the tank, being filled with a mixture of solid and liquid which has a considerably higher specific gravity than clear solution, is capable of exerting a greater pressure per foot of height than clear solution.

Consider the bottom compartment. A pipe is connected at the outside edge near the top of the compartment for drawing off clear solution. This pipe rises to connect with a steel box at the top edge of the tank. The pressure of the pulp in the center of the tank causes the clear solution to discharge at a considerably greater height than the fluid-level at the top of the tank. The clear solution overflows in the box and is fed by gravity to the center of the next higher compartment through a pipe. The amount of the flow can be regulated by altering the height of the pipe discharging into the box. For this purpose rings cut from pipe are provided. The length of these rings along the pipe varies from half an inch to several inches. The adjustment is a delicate one, and the addition of a $\frac{1}{2}$-inch ring may practically stop the flow. The same applies to the other compartments, but the difference in pressure decreases in the higher compartments and for each successive overflow-line, there is a decrease in the height to which the solution rises. The main point in operating a thickener is to draw off a ton of solids for each ton fed. Some operators have a tendency to let the solids accumulate in the thickeners. However, with these tray thickeners it is also very important to hold down the pressure beneath the trays, as well as to keep solids from accumulating on them.

Consider the washing thickener. Suppose that it is heavily loaded with slimes and that many rings have been added to solution-discharge-lines to hold down the overflow. Suppose that a sudden decrease in the slime-content of the ore causes an equally sudden decrease in the density of the central pulp column of the thickener. The back pressure from the overflow lines might build up such a heavy load on the bottoms of the trays that they would be raised from their supports. For this reason trays must be very securely welded to supports during construction.

Present adjustment of the washing thickener is such that solution-lines overflow when the load in the pulp-column is at its probable minimum. When this adjustment is maintained, operation of the thickener is practically automatic. Other adjustments can be made by altering the amount of underflow handled by the diaphragm pump, raising the rakes and thus altering the amount of seal between compartments. or changing the settling rate of the slime with caustic starch, which is described in more detail below.

The primary thickener is used more or less as a batch machine, and overflow from lower compartments is often adjusted with rings.

Other adjustments mentioned in the foregoing paragraph can be made also.

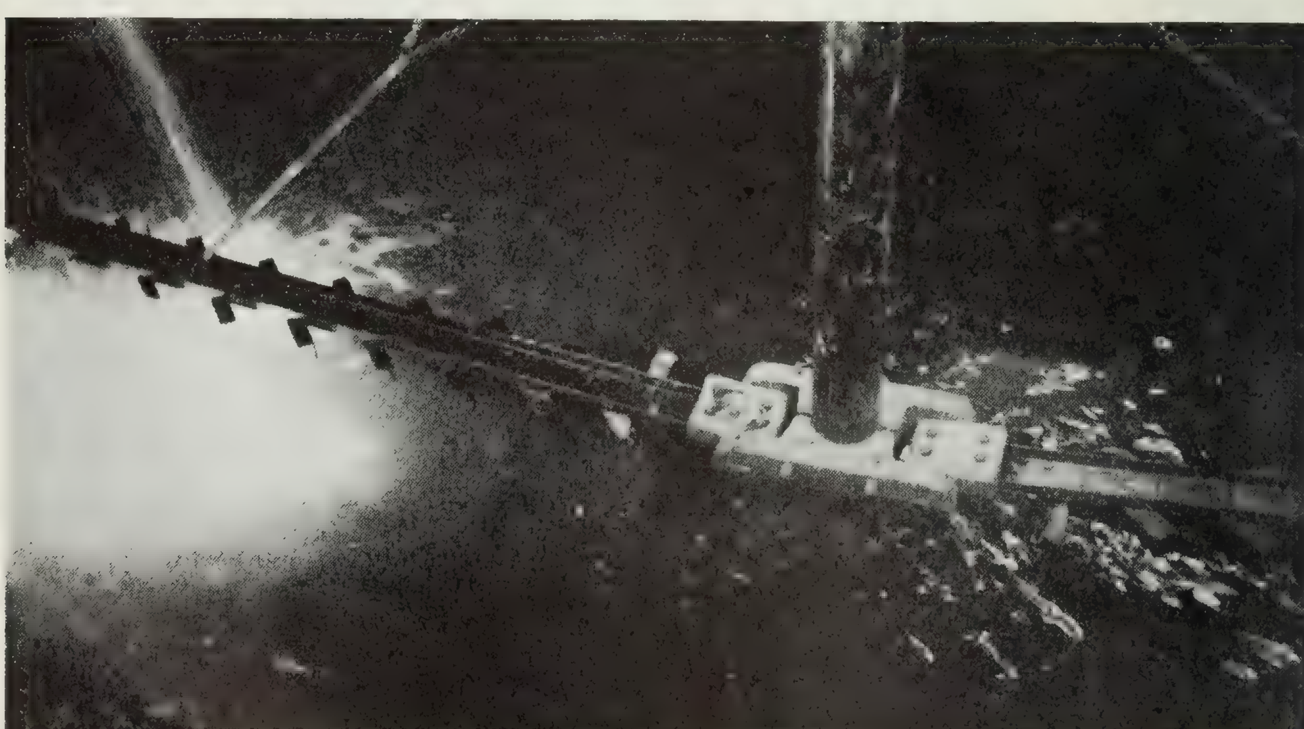
Slime treatment, details.

Slime overflows the periphery of the bowl classifier over an adjustable weir, and flows through a launder to a trash-trommel. It is 14 inches in diameter at the feed end, 30 inches in diameter at the discharge end, and 42 inches long, and is made of screen with 3½ meshes to the inch of No. 12 wire. It discharges on two sets of tray-screens of the same mesh and wire set directly over the surge sump. The trash-trommel is driven at 32 rpm. by a ½-hp. direct-connected Pacific G. E. gear-motor. The bowl classifier overflows at approximately 300 gallons per minute of pulp containing 15% solids. Solution to make up this volume comes from the hammer-mill and from the rake-compartment of the classifier. Screen analysis of the slime by Tyler standard screens follows:

95%		minus	120	mesh
3%	on 120	minus	85	mesh
2%	on 85	minus	60	mesh

The surge sump is a 4-ft. by 4-ft. by 5-ft. tank connected by a 6-inch pipe to the suction of a B-frame Hydroseal slurry pump. This is driven at 840 rpm. by a 10-hp. motor, which actually draws 4.8 hp. Gland solution (barren solution) is supplied to this pump by a Wesco all-iron pump driven by a ¼-hp. motor at 1800 rpm.

The Hydroseal pump discharges against a static head of 30 ft. through approximately 260 ft. of 5-inch pipe to the feed-box of a 40 by 24-ft., type A2TB Dorr balanced tray thickener with three compartments. The feed is split so that one-third of it goes to the feed well of each of the three compartments. Supernatent solution overflows a standard weir at periphery of top compartment, and from 4-inch pipes connected to lower two compartments. Overflow boxes, with their rings for adjusting flow, are arranged at 120° from each other around the top of the tank. Overflows are combined in a sump, from which solution is pumped to mill storage by an Ingersoll Rand Cameron cen-



PHOTOGRAPH 6. Rakes in bottom of agitator. (Photo by D. L. King.)

trifugal pump directly connected to a 15-hp., 3450-rpm. motor. The central shaft carrying rakes for all three compartments is driven at 0.162 rpm. by a 130 to 1 turret drive unit, which is in turn driven by a 68-rpm. Watson Flagg G. E. gear-motor through a chain and sprocket. The turret drive mechanism is protected by a dynamometer overload indicator, which signals overloads, and finally stops the motor for a heavy overload. Combined underflows from the three compartments are handled by a Dorrco No. 4 SSM simplex diaphragm pump, which discharges to a small sump. This pump is driven by a 2-hp., 65-rpm. Watson Flagg G. E. gear-motor.

The pulp then flows by gravity through a 6-inch line, about 60 ft. long, to the first of two stages of agitation. Agitators are redwood tanks, 25 ft. 8 inches inside diameter, with 13-ft. staves. They are equipped with standard type A Dorr agitator mechanism. This includes a central air-lift, 4 inches in diameter, fed by a 1-inch air line. A pair of arms extending across a diameter of the tank at the bottom carries rakes, and at a right angle, at the top of the tank, another pair of arms carries launders to distribute the pulp from the air-lift. These arms are turned at 4 rpm. by V-belt drive and turret mechanism with ratio of 130 to 1 connected to a 3-hp., 1200-rpm. motor. Air is supplied at 40 cu. ft. per minute and 20 lb. per square inch pressure to each agitator by a 7-inch by 4-inch single-stage, type A3 Pennsylvania air-cooled compressor driven by a short-center V-belt drive connected to a 7½-inch hp. motor of 1200 rpm. Underflow from the primary thickener is 40% solids, while pulp in agitators is 30% solids by weight. Dilution is effected from mill storage. Time of contact in agitators varies from 12 hours to 20 hours depending on the tonnage of slime treated on the day in question. This varies from 180 tons to 315 tons.

Pulp goes from one agitator to the next by gravity. Overflow from the second agitator goes through a 4-inch pipe to a repulping device of local design and manufacture. It is a cylindrical tank made of ⅛-inch steel, and is 4 ft. in diameter by 7 ft. high. In the bottom is a cast impeller with two blades of 24 inches set at a pitch of 45°. This is driven from the top of the tank by a 5-h.p., 1800-rpm. motor and Boston [6] right-angle speed reducer. To break up the turbulence, a vertical baffle of ½-inch plate punched with 1-inch holes occupies about 60% of the effective height of the tank. Solution is fed to this repulper by a 4-inch syphon line controlled by a float. The supply is from No. 2 compartment (2d from top) of the washing thickener. Underflow from the repulper is pumped against a 40-ft. static head through about 100 ft. of 3-inch pipe to the feedwell of the washing thickener. A Wilfley pump driven at 1800 rpm. by direct connection to a 15-h.p. G. E. motor is used.

The Dorr type A3TW washing thickener is a welded steel tank, 50 ft. in diameter by 36 ft. high, with three trays or four compartments. Rake mechanism is similar in design and power (3 h.p.) to that on the primary thickener. It turns at 0.169 rpm. This washing thickener is a complete counter-current decantation unit. Compartments are numbered starting with No. 1 at the top. Thickened pulp from No. 1 compartment is admitted through a hydro-seal into the feedwell of No. 2 compartment, where it joins with the overflow from No. 3 com-

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[6] Boston Gear Works, Boston, Mass. or c/o C. W. Marwedell, San Francisco.

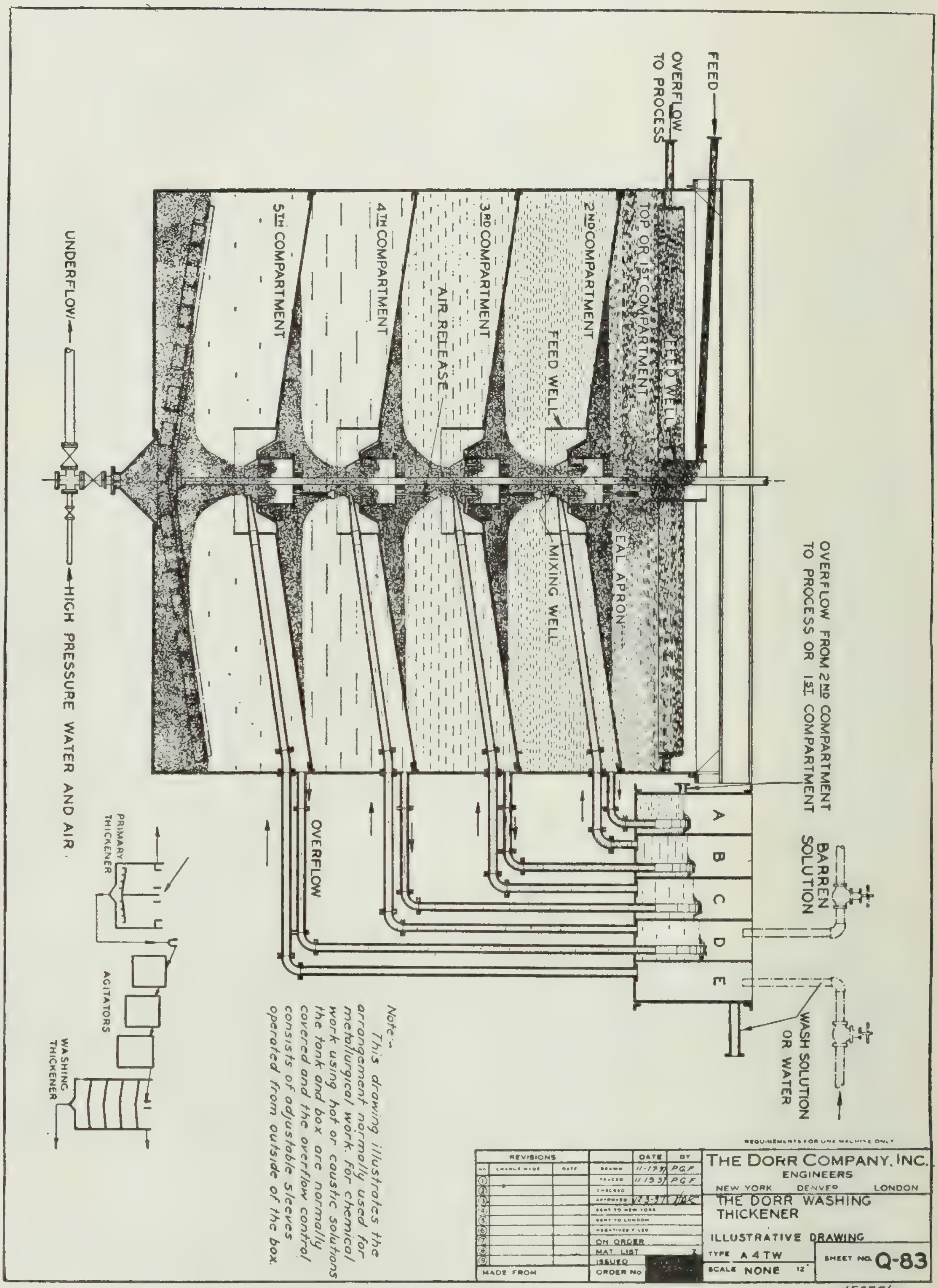


FIG. 2. Washing thickener. (By courtesy The Dorr Company, Inc.) Stippled parts represent settled solids. Horizontal dots represent dissolved value in liquid. Their number is roughly proportional to dissolved value contained.

partment. Overflow from No. 2 compartment is split by the siphon line so that about 50% goes by gravity to the repulping tank; the balance goes to the feedwell of the top compartment to join with the pulp entering the feedwell. Underflow of thickened pulp from No. 2 compartment passes through the seal into the feedwell of No. 3 compartment, where it joins with the advancing overflow of solution from No. 4 compartment and added barren solution. Underflow of thickened pulp from No. 3 compartment passes through the seal to No. 4 compartment, where it joins with wash solution (barren solution) and water. Underflow from No. 4 compartment is the final slime tailing. It is pumped by a No. 4 SSM Dorrco simplex diaphragm pump connected directly to a 2-h.p., 65-rpm. Watson Flagg G. E. gear-motor. This pump discharges into a small steel sump-box, which in turn discharges into a meter, from which the slime-tailing is pumped underground to the old No. 8 copper mine for disposal. Meter and tailing-disposal are both described in more detail below.

Solution overflowing the weir at the top of the washing thickener goes by gravity through a 4-inch pipe into a steel sump tank made of 10-gage iron, 10 ft. in diameter by 10 ft. high, from which it is pumped back to grinding and classification through 450 ft. of 4-inch pipe. The pump is a Pennsylvania motor pump, a single-stage centrifugal of 20 h.p. running at 3450 rpm.

Meter.

To measure the amount of the slime tailing, a meter was designed and built locally. It consists of two steel tanks each 4 ft. by 4 ft. by 4 ft. made of reinforced 10-gage iron. These are fed by gravity from the sump below the diaphragm pump which handles the final underflow from the washing thickener. The tanks are arranged with both low-level and high-level floats and valves so that one is filling while the other is being pumped out, and the number of times that this is done is counted by a Veeder counter. Valves are 3-inch, three-way, two-port, No. 3465, lubricated, semi-steel, multiport, Nordstrom valves. Two of them are connected to the output shaft of a Boston VAAW, 450 to 1 speed reducer driven by a $\frac{1}{4}$-h.p., 1800-rpm., 440-volt, 3-phase, 60-cycle induction motor. This motor is started in forward and reverse rotation by the floats in the tanks to effect the proper filling and pumping out. 'Limit-switches' are provided to stop the rotation of the valve-shaft at the proper points. Floats are connected electrically in such a way that only full tanks can be pumped out.

From the two compartments of the meter, the slime is pumped out by an A-frame Hydroseal slurry pump powered by a 5-h.p., 1800-rmp. motor through a short-center V-belt drive imparting 1200-rpm. to the rotor of the pump. This pump has 250% of the capacity of the diaphragm pump feeding the meter, and runs intermittently depending on the positions of the floats in the meter tanks. A solenoid control with time-delay relay turns on gland water from the pressure system six seconds before the pump starts. Gland water can not be left on continuously because it would back up into the meter tanks and destroy the accuracy of the meter.

Tailing-disposal.

The discharge of the A-frame Hydroseal pump is connected by approximately 1000 ft. of 6-inch pipe to the extensive underground workings of the old No. 8 copper mine, which is being back-filled with slime tailing. Water now coming from the mine appears perfectly clear. Hence no slime tailing is entering surface drainage.

Scavenger system.

The foundation of the classifier and the drain-apron of the hammer-mill are connected by gravity to a scavenger sump, a cylindrical steel tank 15 ft. by 15 ft. An apron on the trash screen and the floor of the B-frame pump house also drain into this sump. It is pumped out intermittently by a 2-inch Wilfley pump, which returns the pulp to the grinding and classification circuit.

Precipitating.

The Merrill-Crowe vacuum process is used to precipitate gold from solution. A vacuum pump working on a steel tank de-aerates the solution before precipitation. Ahead of de-aeration, and after it leaves the gold-solution tank, the solution passes through two units of clarification. Each of these is composed of 16 Butters type clarification leaves, 5 ft. by 7 ft. The clarified solution is admitted directly into the vacuum tower, and thus simultaneous clarification and de-aeration are effected. The vacuum pump supplies power for both of these steps. It is a 6-inch by 4-inch Ingersoll Rand single-stage vacuum pump driven through a V-belt drive by a 2-h.p. G. E. motor of 1800 rpm.

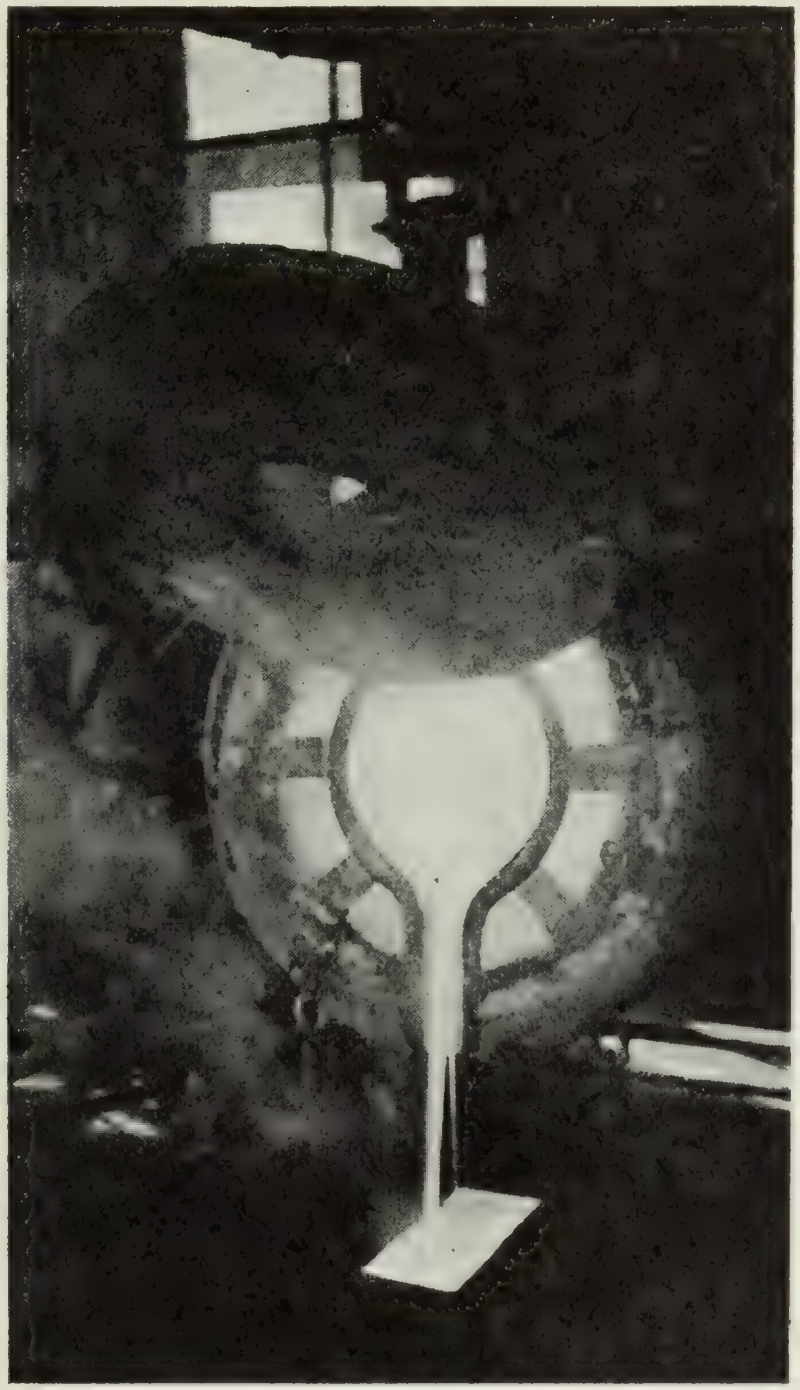
To collect precipitate, small canvas filter leaves, 3 ft. by 3 ft., submerged in a small tank with an agitator of the propeller type in the bottom, are used. Zinc dust is fed to this tank and precipitation takes place in it. At time of cleanup, the contents of this tank and washings from the filter leaves are transferred to a second tank with a filter bottom, where as much moisture as possible is removed with the vacuum pump. Two centrifugal pumps circulate the solution; one is a 4-inch pump driven by a 7½-h.p. motor of 1800 rpm., the other a 2½-inch pump driven by a 10-h.p. motor of 1800 rpm. After a cleanup, precipitation is started again by feeding 10 lb. of zinc dust immediately, then 11 lb. per 8-hour shift. The ore contains mercury, which appears in the precipitate to the extent of 16% of its weight, and which is believed to aid precipitation. Barren solution from this process never assays more than a trace of gold. Each operator makes a colorimetric test (purple of Cassius) twice a shift to detect any gold entering the barren solution circuit. Precipitation is at the rate of 1000 tons of solution per day, or 1.3 tons solution is precipitated for each ton of ore treated.

Melting precipitate.

Precipitate is melted in a No. 200-crucible tilting furnace burning distillate, with the following flux to each 100 lb. of wet precipitate: 12 lb. sodium carbonate, 17 lb. sand, 22 lb. borax, 3 lb. manganese dioxide, 1½ lb. niter, and 3 lb. fluorspar. Slag is decanted into a conical mold down to near the metal line; the bullion is poured in a standard bullion mold. Fineness of bullion averages 400 parts gold, 550 parts silver, and 50 parts base, mostly copper.

Slag from the melt is ground in a 24-inch ball mill and fed to a Deister concentrating table, from which three products are taken.

Concentrate is returned for re-melting in the next melt, middling is re-ground, and tailing is agitated in a 4-ft. by 7-ft. Devereaux type agitator. Solution contains 10 lb. cyanide (KCN) per ton, and two tons of solution are used per ton of slag. Batch decantations from this agitator are admitted into the mill gold circuit. Slag-tailing is thus reduced to a gold content of $3 per ton and a silver content of $5 per ton and is discharged to waste.



PHOTOGRAPH 7. Pouring gold bullion.
(Photo by D. L. King)

Caustic starch.

The plant was designed and built to treat 150 tons of dry slime per day on the basis of a normal settling requirement of 10 sq. ft. settling area per ton per 24 hours. Subsequently it became necessary to treat 185 to 315 tons of slime per day, and the settling characteristics of the ore had to be changed. Extensive tests demonstrated that this could be done with caustic starch used at the rate of $\frac{1}{2}$ lb. to 1 lb. per ton of dry slime.

It is made by digesting with steam a mixture of 100 lb. tapioca flour and 12 lb. of flake caustic soda (lye). It is diluted to contain roughly 1 lb. tapioca flour per gallon of solution. A manifold is provided at the feed box of the primary thickener, where it can be added

as needed. A similar arrangement is provided at the overflow boxes of the washing thickener.

Other chemicals and solutions.

Lime is added to sand-percolation by a feeder over No. 3 conveyor, feeding 8 lb. of 10-mesh quicklime per ton of dry sand. In addition to this, 'milk of lime' is added to both mill solution storage tanks, to barren solution storage tank, to classifier circuit, and to primary thickener underflow. Lime thus added is slaked in an Orinda type slaker consisting of a vibrating hopper feeding a flight conveyor, which admits prepared lime into the slaking chamber. This consists of two lawn-mower type blades revolving into each other. Water is added here. The slaker handles a ton of lime per day. This lime is air-floated, 150-mesh, running 90% to 92% CaO. It costs \$20 per ton delivered to the mill in 60-lb. bags. The 10-mesh lime costs \$18 per ton delivered. Cyanide used is in 1-lb. bricks running 94% sodium cyanide (NaCN).

All effluent solutions coming from sand-percolation are acid, containing hydrogen cyanide (HCN). This is the reason for adding lime to solution tanks. The hydrogen cyanide is converted into calcium cyanide. Mill solution contains $1\frac{1}{2}$ lb. cyanide (titrated as KCN) and 0.4 lb. lime per ton. Barren solution contains 0.8 lb. cyanide and 0.4 lb. lime per ton. Gold solution is acid, requiring 0.2 lb. sodium hydroxide (NaOH) per ton to neutralize. It contains 0.4 lb. cyanide (titrated as KCN) and about 1 dwt. gold per ton. The four main solution tanks are 25 ft. 8 inches in diameter by 12 ft. high, and are set on high ground. Two are used for mill solution, one for gold solution, and one for barren solution. The gold solution tank has a filter-bottom covered with two feet of coarse sand. Water consumption is 0.6 ton of water per ton of ore. In the slime tailing, 330 tons are discharged daily; the balance is lost as moisture in the sand tailing and by evaporation. No lead acetate is now used in the mill.

Approximate distribution of cyanide consumption is calculated as follows:

Washing thickener, 330 tons at 0.172 lb. NaCN per ton	56.76 lb.
Sand tanks, 11% barren solution as moisture	32.21
Mechanical loss per day	88.97
Mill stock contains 1.125 lb. NaCN per ton. It is put on sand tanks at this strength and comes off at 0.60 lb. per ton, a difference of 0.52 lb. per ton.	
Six tanks at 6 tons per hour for 24 hours gives 864 tons at 0.52 lb. per ton,	
Consumed in sand-leaching	450
	539
Cyanide used is 94% NaCN. 539 divided by .94, Commercial cyanide used per day	573 lb.
Actual amount used per day in June, 1938	586 lb.

The difference is no doubt due to chemical consumption in the slime circuit, which is known to be low, but which is not readily calculated because solutions in the washing thickener are in a partly closed circuit.

Sampling.

For mill-heads, a sample is taken from No. 2 conveyor by hand every 30 minutes. The sample weighs about 150 lb. to each sand-tank filled. Sand-head sample is taken every 30 minutes from the tripper. The classifier man takes a sample every 30 minutes to control density of pulp, and an aliquot part of this is saved for assay of classifier overflow or slime-heads. Sand tailing is sampled at discharge by hand. Slime tailing is sampled automatically by an arm attached to the valve mechanism of the meter. A cup cuts an aliquot part of each meter-load, and discharges into a hermetically sealed container, which is equipped with a valve that closes as soon as the sample has passed through it. All sand effluent solutions are assayed daily as well as gold solution (precipitation-heads) and barren solution (precipitation-tails). Sand tonnages are estimated by the use of a 3-cu. ft. weight box installed in one of the sand-tanks. Slime tonnages are metered as already described.

Laboratory.

A complete analytical laboratory for qualitative and quantitative work is maintained in addition to the assay office. Metallurgical testing-apparatus for cyanidation, flotation, and amalgamation is also provided.

One interesting problem solved is the detection of water-soluble gold. Difficulty was at one time experienced in making assay-values check with mill-recovery. Experiments showed that in some samples as much as 44% of the gold would dissolve in distilled water. This gold was at first supposed to be in a colloidal state, but tests proved that it is not. Finally micro-chemical tests with pyridine [7] showed the presence of gold chloride ($AuCl_3$). Of the gold in the ore, it is not unusual for 10% to 15% to be in this water-soluble form. All of the ore does not contain it.

Crew.

The mill crew consists of 3 loading crews of 3 men each (1 crusher man, 1 classifier man, 1 distributor man), 2 discharging crews of 3 men each, 3 solution men, 1 pipe-fitter, 2 mechanics, 1 assayer, 1 assayer's helper, 1 research man, 1 electrician, 3 general laborers, and 1 mill superintendent—total 29. Minimum wages are $4.25 per 8-hour shift.

[7] Directions for pyridine test are given by Short, M. N., Microscopic determination of the ore minerals, U. S. Geol. Survey Bull. 825, pp. 153-154, 1931.

CYANIDE PLANT REPORT FOR JUNE, 1938

Total tonnage treated	22,434	tons
Crushing hours	572 ½	
Tons crushed and treated per day (30 days)	747.8	
Tons crushed per hour (572½ hours)	39.19	
Tons of dry sand treated (63 charges)	15,370	
Tons of dry slime treated	7,064	
Per cent of mill feed to sand treatment	68.51%	
Per cent of mill feed to slime treatment	31.49%	
Average mill heads, gold	1.0960	dwt.
Average silver content of mill heads	0.1434	oz.
Average sand heads, gold	0.9075	dwt.
Average total sand tails (residue and soluble)	0.0314	dwt.
Indicated sand extraction	96.54%	
Average classifier overflow (total slime heads)	1.8186	dwt.
Average washing thickener underflow residue loss	plus trace	dwt.
Average washing thickener underflow soluble loss	0.0913	dwt.
Indicated slime extraction	94.98%	
Indicated sand and slime overall extraction, prorated	96.05%	
Actual mill heads—(bullion plus tails by tonnage)	1.1617	dwt.
Actual overall extraction—(total: 24,935 dwt.)	95.67%	
Indicated gold content (actual)	26,061.58	dwt.
Indicated silver content—(0.1434 x 22,434)	3,194.60	oz.
Actual silver extraction—(bullion: 1,711.00 oz.)	53.56%	
Tons of dry slime treated per day	235.5	
Tonnage of solution precipitated for the month	28,841	
Average tons of solution precipitated per day	961	
Pounds of tapioca flour used per ton of slime treated	0.998	
Caustic soda used to digest starch used for month	846	lb.
Pounds of lime used per ton of ore treated	7.787	
Pounds of zinc used per ton of solution precipitated	0.035	
Pounds of zinc used per ton of ore treated	0.044	
Pounds of cyanide consumed per ton of ore treated	0.784	
Cost per ton for reagents (total: $4,221.10)	18.82¢	
Gold in bars #320 and #321	24,935.00	dwt.
Silver in bars #320 and #321	1,711.00	oz.

Costs.

The following milling costs per ton apply to the tonnage treated in June, 1938, as given above. No amortization of plant, no taxes, and no general expense other than that at Iron Mountain are included. No mining costs are included.

Labor	$0.145
Reagents	.188
Other materials	.045
Laboratory	.022
Power	.051
Iron Mountain general	.022
Administration and overhead	.047
Haulage	.009
Tailing disposal	.05
Express on bullion	.002
Total milling cost per ton	$0.581

USE OF ULTRA-VIOLET LIGHT IN PROSPECTING FOR SCHEELITE

By Ott F. Heizer *

The use of ultra-violet lamps for the detection of scheelite by fluorescence has proven such a boon to the prospector, miner, and mill-man engaged in the search for or reduction of tungsten ores carrying scheelite, that some information on the highly interesting development is timely.

Scheelite, the tungstate of lime, $CaWO_4$, is the most important tungsten mineral mined in the Americas. Comparatively smaller amounts of ferberite, the tungstate of iron, hübnerite, the tungstate of manganese, and wolframite, the combined tungstate of iron and manganese in varying amounts, are produced but they fall without the scope of this discussion, as these dark minerals show no excitation by ultra-violet light. The examination of many specimens of these dark tungsten minerals by ultra-violet light, however, discloses hitherto unsuspected marginal alteration of certain of the dark minerals to scheelite. Cupro-scheelite, a green tungsten mineral in which a part of the calcium has been replaced by copper, usually shows a pale-blue fluorescence. The other and rarer tungsten minerals, none of which occur in commercial amounts (powellite, a calcium tungstomolybdate, stolzite, a lead tungstate, and tungstenite, a sulphide of tungsten), exhibit no fluorescence.

Scheelite, when in mass, is distinguished by its high specific gravity of 5.5 to 6. In color it may vary from snowy white to almost black. Pale-yellow, pink, and brown colors are common. It has a very distinctive greasy luster, and good cleavage in 4 directions. Because some of the other and more common minerals, such as barite and the oxides and sulphates of lead, are likewise heavy and of similar colors, it is not always easy to distinguish scheelite from them in the field with the unaided eye. When scheelite occurs in small isolated grains in heavy ores of the garnet type, its identification is difficult, as such ores usually also show milky quartz grains and intersticial calcite. It is also usually difficult to identify scheelite grains in massive quartz veins by visual inspection, particularly where there is iron staining. Scheelite has a hardness of about 5 and can be easily scratched by the blade of a good knife and thus distinguished from either quartz or calcite. Regardless of its color, scheelite has a white streak; this streak can be obtained by rubbing the mineral on a piece of unglazed porcelain. Crushing and panning offers a good method of determining scheelite, as the mineral 'hangs back' in the pan almost as does gold. The white concentrate, if any be obtained by panning, can be tested by transferring it to a test tube and boiling with a mixture of three parts of hydrochloric (muriatic) acid and one part of nitric acid and adding a small amount of metallic zinc. A blue color will indicate tungsten.

Probably the simplest and most definitive means for determining the mineral scheelite qualitatively is by use of the ultra-violet lamp. It

* General Manager, Nevada-Massachusetts Company, Inc., Mill City, Nevada. Manuscript submitted September 10, 1938.

is made in several models, for use on a power circuit or with either wet or dry storage-batteries. Ultra-violet lamps are of two general types, the so-called iron-arc type which employs a high-tension disruptive spark for producing the proper radiation, and the quartz-tube type in which high-tension current is passed through a quartz tube containing mercury. The latter type has the advantage of greater portability and absence of noise from the arc. Both types are manufactured and sold by several chemical and supply houses. A highly satisfactory lamp weighing 10 pounds with its batteries, contained in a box measuring 4½ by 11 by 8 inches, and powered by two dry-cells, having a life of over two hours in constant use, has been developed and is employed by the Nevada-Massachusetts Company at its various scheelite properties in Nevada. This lamp is not on the market.

The use of a filter on the lamps is advantageous but not essential. The most satisfactory one has been Red Purple Corex A No. 986 made by the Corning Glass Works. This filter transmits the maximum amount of short wave-length radiation between 2500 and 3000 Ängstrom Units and gives the best results for the detection of scheelite. With the quartz-mercury-tube type of lamps the best effects are not visible until the current has been applied to the tube for three or four minutes. With such a lamp equipped with filter, the most minute specks of scheelite are visible. There is a tendency however, to over-estimate the amount of scheelite when it is viewed with the filter.

When ultra-violet light of the proper wave-length is directed on certain minerals it causes them to glow or fluoresce. These minerals absorb ultra-violet radiation and transform it into colors in the visible spectrum. While this phenomenon has been long recognized, only recently has it been applied to the detection of scheelite, one of many susceptible minerals. Regardless of the color of the scheelite to the unaided eye, whether white, pale-blue, cream colored or yellow, the fluorescence is quite unmistakable.

It is advisable to exclude from the mineral being examined under ultra-violet light as much outside light as possible; the best effects are obtained in total darkness. A flash light, since it is easily turned off, may be used to advantage underground instead of the usual carbide lamp. On rock outcrops one method to exclude light is to drape a blanket over the head; another is to make use of some sort of a hood having a soft heavy curtain on the bottom with an opening on the top only large enough for the eyes, and a slit or self-closing opening for inserting the lamp. With such a device fairly good results may be obtained on outcrops exposed to the sunshine.

Hyalite, a colorless variety of opal which occurs as the lining of vugs, or as thin coatings on many rocks, exhibits a brilliant green fluorescence. The zinc ores from Franklin Furnace, New Jersey, show very brilliant colors under ultra-violet light, the calcite being a deep pink and the zinc minerals vivid greens and yellows. A variety of calcite from Texas fluoresces deep-blue and holds the color for several minutes. Coatings of talc in broken limestone beds and garnetiferous contact-metamorphic scheelite deposits sometimes show a yellow or greenish color, but because of their abundance can not be mistaken for scheelite. Occasionally colored minerals under the lamp are somewhat deceptive and the question arises whether or not fluorescence is being

observed; this can be decided by holding a piece of glass or cellophane over the mineral. If the color persists when the mineral is so covered, fluorescence is absent.

Scheelite has a distinct glow under the ultra-violet light, whereas the other minerals which might be confused with it (except the New Jersey zinc ores the colors of which are too distinctive to be confused with scheelite) are more dull. Because of the usual habit of scheelite to occur in grains and because of its distinctive glow, the operator after a short experience should have no doubt of its identification. Small droplets of oil or grease thrown on the ore from drilling operations fluoresce almost as brightly as scheelite, but a touch of the finger dispels the similarity.

Care should be exercised not to look directly at the lamp as its effect on the eyes is almost as serious as that of an electric welding arc.

The ultra-violet lamp has also been found valuable in milling operations for observing losses in tailings, in magnetic separator rejects, and for inspecting floors and leaky launders for spills.

The zone of separation between scheelite ore and gangue passing over concentrating tables can be definitely determined by darkening the mill and using an ultra-violet lamp with the tables in operation.

While the use of ultra-violet light is essentially a qualitative method, an experienced operator (after checking typical specimens by panning and assay) can make a very close estimate of the grade of ore. In examination by ultra-violet light, allowance must be made for the fact that scheelite from different ore deposits may show different degrees of fluorescence. It is difficult, therefore, to form a close estimate of grade of ore from a deposit where the operator has no criterion based on assay.

Recent improvements in the field of ultra-violet apparatus open up possibilities for more intensive and intelligent search for scheelite deposits than has heretofore been possible. Unquestionably many areas which have been superficially looked over should now be more carefully examined at night with ultra-violet lamps, and indications of any scheelite mineralization followed up by trenching in order to expose fresh surfaces for further detailed examination.

It must be borne in mind when using the ultra-violet lamp that even a slight film of iron oxide, mud, or other material coating the mineral will screen out the ultra-violet rays and prevent fluorescence. Night prospecting has been successfully carried on with ultra-violet lamps powered by small gasoline-driven generators. Some complete portable outfits may be purchased weighing as little as 45 pounds, with lamp cords as long as 150 feet. Three or four lamps can be used to one generator of 175 watts.

It is good practice to mark favorable spots for finding ore with a daub of bright paint or with a sheet of note paper weighted down by a rock. Then, in ordinary light, these particular spots can easily be relocated.

NEW STATE LANDS ACT OF 1938

An act relating to lands owned by the State; reserving all minerals and all oil and gas in State lands; providing for prospecting for and taking such minerals and for the extraction and removal of oil and gas therefrom; providing for the acquisition by purchase or condemnation of interests in privately owned lands to facilitate the operations provided for or contemplated by this act; creating a State Lands Commission, prescribing its powers and duties, and transferring to and vesting in the State Lands Commission the administration of and jurisdiction over State lands; repealing acts or parts of acts in conflict herewith; and making an appropriation.

Approved by the Governor, March 24, 1938

The people of the State of California do enact as follows:

SECTION 1. This act shall be known and may be cited as the "State Lands Act of 1938."

Article 1. General Provisions and Definitions.

SEC. 3. Unless the context otherwise requires, the general provisions and definitions hereinafter set forth shall govern the construction of this act.

SEC. 4. The present tense includes the past and future tenses; and the future, the present.

The masculine gender includes the feminine and neuter.

The singular number includes the plural, and the plural the singular.

SEC. 5. "City" includes "city and county."

"Shall" is mandatory and "may" is permissive, but whenever permissive authority or discretion is vested in any public officer or body under this act, such authority or discretion is subject to the condition that it be exercised in the best interests of the State.

"Commission" means the State Lands Commission created by this act.

"Oil and gas" includes oil, gas and all other hydrocarbon substances.

"Minerals" includes all substances other than oil, gas and other hydrocarbon substances.

Article 2. The State Lands Commission.

SEC. 11. There is hereby created in the Department of Finance a State Lands Commission to consist of the State Controller, the Lieutenant Governor, and the Director of Finance. The commission shall succeed to and is hereby vested with all the powers, duties, purposes, responsibilities and jurisdiction of the Department of Finance as successor to the Surveyor General, Register of the State Land Office, and State Land Office, under section 690 of the Political Code, and of the Division of State Lands in the Department of Finance. Whenever, by the provisions of any statute or law now in force or that may be hereafter enacted, a duty or jurisdiction is imposed or authority conferred upon the Surveyor General, Register of the State Land

Office, or State Land Office, or upon the Department of Finance as successor thereto, or upon the Chief of the Division of State Lands, or the Division of State Lands, such duty, jurisdiction, and authority are hereby transferred to, imposed and conferred upon the commission hereby created and the appropriate officers and employees thereof with the same force and effect as though the title of the State Lands Commission had been specifically set forth and named therein in lieu of the Surveyor General, Register of the State Land Office, State Land Office, Department of Finance, Chief of the Division of State Lands, or Division of State Lands, as the case may be.

The statutes and laws pertaining to matters formerly under the jurisdiction of the Surveyor General, Register of the State Land Office, State Land Office, the Department of Finance as successor thereto, the Chief of the Division of State Lands, and the Division of State Lands, and all laws prescribing their duties, powers, purposes, responsibilities, and jurisdiction, together with all lawful rules and regulations established thereunder, are hereby expressly continued in force except as herein repealed or amended.

The commission shall be in possession and control of all records, books, papers, offices, equipment, supplies, lands or other property, real or personal, now or hereafter held for the benefit or use of the Department of Finance, as successor to the Surveyor General, Register of the State Land Office, and State Land Office, and of the Chief of the Division of State Lands and the Division of State Lands.

Sec. 12. The commission shall administer this act and all laws and statutes committed to it by this act through the Division of State Lands of the Department of Finance, which division is hereby continued in existence. The commission is hereby vested with all the powers conferred upon heads of departments of the State contained in sections 352, 353 and 356 of the Political Code.

The commission may appoint and, with the approval of the Director of Finance, may fix the salaries of such officers and employees in the Division of State Lands as may be necessary for the conduct of the work of the commission.

Sec. 13. The commission shall meet, upon due notice to all members thereof, at such times and places within the State as are deemed necessary by it for the proper transaction of the business committed to it.

Sec. 14. The commission shall adopt rules governing the conduct of the business of the commission, and no action of the commission shall be valid unless authorized by resolution adopted at a meeting after due notice thereof and by at least two of the members of the commission present.

Sec. 15. The commission is hereby empowered to authorize any of its employees or officers to execute any instrument in the name of the State of California, pursuant to resolution adopted by the commission.

Sec. 16. Whenever the commission, pursuant to the authority herein granted, enters into any agreement for the compromise or settlement of claims, such agreement shall be submitted to the Governor, and if approved by him shall thereupon, but not before, be binding upon the State and the other party thereto.

Sec. 17. The commission may from time to time classify any or all State land for its different possible uses, and, when it is deemed advisable, may require the Department of Natural Resources, the Director of Agriculture, or any other officer, organization, agency or institution of the State government to make such classification. It is hereby expressly made the duty of any such officer, organization, agency, or institution to make such classification and to render a report thereon upon the application of the commission.

Sec. 18. The commission may make and enforce all reasonable and proper rules and regulations consistent herewith for the purpose of carrying out the provisions of this act and incidental thereto, and may do any and all things necessary fully and completely to effectuate the purposes of this act.

Article 3. Provisions Relating to All State Lands.

Sec. 31. All oil, gas, oil shale, coal, phosphate, sodium, gold, silver, and all other mineral deposits in lands belonging to the State, or which may become the property of the State, are hereby reserved to the State, except that nothing in this act applies to lands acquired by the State on sale thereof for delinquent taxes, other than lands so acquired, the deed for which is required to be filed in the office of the Department of Finance or of the commission. Such deposits are reserved from sale except upon a rental and royalty basis as herein provided. A purchaser of any lands belonging to the State, or which may become the property of the State, shall acquire no right, title, or interest in or to such deposits. The right of such purchaser shall be subject to the reservation of all oil, gas, oil shale, coal, phosphate, sodium, gold, silver, and all other mineral deposits, and to the conditions and limitations prescribed by law providing for the State and persons authorized by it, pursuant to this act or otherwise, to prospect for, mine, and remove such deposits, and to occupy and use so much of the surface of said land as may be required for all purposes reasonably extending to the mining and removal of such deposits therefrom. The provisions of this section shall not apply to any compromise agreement entered into under this act.

Sec. 32. (a) All applications to purchase State lands which are hereafter filed, and all sales pursuant thereto, shall be subject to and contain a reservation to the State of all oil, gas, oil shale, coal, phosphate, sodium, gold, silver, and all other mineral deposits in all lands so acquired, and shall also contain a reservation to the State, and persons authorized by it, of the right to prospect for, mine, and remove such deposits and to occupy and use so much of the surface as may be required therefor, and all certificates of purchase and patents issued therefor shall contain such reservations.

(b) Whenever authorized by law to make grants of land to the United States of America, or to an officer, department, or agency thereof, either in exchange for other lands or otherwise, the commission may make such grants with or without the reservation of deposits of oil and gas and other minerals required by this act.

Sec. 33. A lease or prospecting permit shall be issued only to and held by:

(a) Any person or association of persons who are citizens of the United States or who have declared their intention of becoming such, or who are eligible to citizenship under the laws of the United States and are citizens of any country, dependency, colony, or province, the laws, customs, and regulations of which permit the grant of similar or like privileges to citizens of the United States; or

(b) Any corporation ninety per cent or more of the stock of which is owned by persons eligible to hold a lease or permit under subdivision (a) of this section; or any corporation ninety per cent of the stock of which is owned either by a corporation eligible to hold a lease or permit hereunder, or by any combination of such eligible persons or corporations, or both; or

(c) Any alien person entitled thereto by virtue of any treaty between the United States and the nation or country of which such alien person is a citizen or subject.

Sec. 34. Any interest held in violation of this act shall be forfeited to the State by appropriate proceedings for that purpose brought by the State of California in the superior court for the county in which the property or some part thereof is located, except that any ownership or interest forbidden in this act which may be acquired by descent, will, judgment, or decree may be held for two years and not longer after its acquisition.

Sec. 35. The commission, in its discretion, in issuing any lease under this act, may reserve to the State the right to lease, sell, or otherwise dispose of the surface of the lands embraced within such lease, in so far as the surface is not required by the lessee. If such reservation is to be made, however, it shall be so determined before the offering of such lease.

Sec. 36. A lease or permit issued under the provisions of this act may be assigned, transferred or sublet, with the consent of the commission, to any person, association of persons, or corporation, who at the time of the proposed assignment, transfer, or sublease, possesses the qualifications provided in this act. A lease shall contain provisions to enable the lessee to quitclaim all or any part of the State land covered by such lease and thereby to be released proportionately from drilling obligations or other obligations with respect to the land so quitclaimed or relinquished.

Sec. 37. The commission shall reserve and may exercise the authority to cancel any prospecting permit or lease upon failure of the permittee or lessee (after thirty days' written notice and demand for performance) to exercise due diligence and care in the prosecution of the prospecting or development work or the production work in accordance with the terms and conditions of the permit or lease, and the commission shall insert in every permit or lease issued under the provisions of this act appropriate provisions for its cancellation by the commission in accordance with the provisions of this section.

Sec. 38. Any permit or lease under this act shall reserve to the commission the right to allow, upon such terms as the commission may determine to be just, the joint or several use of such easements or rights of way, including easements in tunnels, upon, through, or in the lands leased or permitted, as may be necessary or appropriate for the working of such lands or of other lands containing the deposits described in this act.

SEC. 39. The commission, in the name of the State of California, may purchase or receive by donation or lease any right of way or easement in real property, or any real property in fee simple, necessary or proper for sites for drilling operations, storage of oil, dehydration plants, absorption plants, or other operations necessary or proper under this act.

SEC. 40. The commission, if it deems such action for the best interests of the State, may condemn, acquire, and possess in the name of the State any right of way or easement, including surface rights for any operation authorized or contemplated under the provisions of this act, that may be necessary for the development and production of oil and gas from state-owned land and for their removal, transportation, storage, and sale, and for such purposes is authorized and empowered in the name of the people of the State of California, to institute condemnation proceedings pursuant to section 14 of Article I of the Constitution and the Code of Civil Procedure relating to eminent domain. The acquisition of such interests is hereby declared a public use.

Prior to the institution of such condemnation proceedings, the commission shall adopt a resolution declaring that the public interest and necessity require the acquisition of such interest in lands for the purpose of performance of the duties vested in this commission by the provisions of this act and that the interest in such lands described in such resolution is necessary therefor. Such resolution shall be conclusive evidence: (a) of the public necessity of such proposed public use; (b) that such property is necessary therefor; and (c) that such proposed public use is planned or located in the manner which is most compatible with the greatest public good and the least private injury.

SEC. 41. Any interests in lands, or lands in fee simple, acquired by the commission by purchase, donation, lease, condemnation, or otherwise, may be made available to any lessee of the State for the purposes contained in this act and upon such terms and conditions as may be determined by the commission.

SEC. 42. The provisions of this act authorizing the commission to acquire interests in real property include the acquisition of structures and improvements situated on lands sold by the State subject to the reservations provided herein. Such structures and improvements shall be acquired, however, only upon the written request of a lessee under this act to whom the State has granted the right to extract the oil and gas or other minerals from such lands, and only upon the agreement by the lessee to reimburse the State for the cost and expense of such acquisition and the deposit by the lessee with the commission of such security as it may require.

SEC. 43. The commission may, prior to the receipt of any bid for a lease under this act, withdraw any offer to receive bids therefor, and it may reject all bids therefor filed pursuant to invitation of the commission. At any time before the awarding of a lease thereon, all or any portion of a tract proposed to be leased may be withdrawn by the commission and eliminated from the proposal.

SEC. 44. Whenever by the terms of this act the commission may grant a lease of State lands, the commission may, in its discretion,

make and execute an easement of surface or subsurface rights, or both, in lieu thereof and upon the same terms and conditions and subject to the same limitations and prohibitions as are provided in this act for a lease of such lands.

SEC. 45. For the purpose of this act, the commission is hereby authorized to enter into agreements with any person, association of persons, corporation, city, or county, or either of them, claiming the oil and gas in lands adversely to the State of California, which agreements may:

(a) Establish the respective interests of the parties to the agreement in the oil and gas underlying such land;

(b) Establish the boundary line between lands claimed by the State and other parties to the agreement in those cases in which oil or gas is known to exist in such lands or in the vicinity thereof;

(c) Fix the amount of damages for past or future production of oil and gas from wells drilled under color of title on or into land claimed by the State.

SEC. 46. The commission, in the name of the people of the State of California, may bring action to determine the title to oil and gas in land against persons, associations of persons, and corporations claiming the same adversely and to recover damages for oil and gas removed therefrom. Any person, association of persons, corporation, or city not a party to such a suit and claiming the oil or gas in said land, or any part thereof, may intervene in such an action and have his rights adjudicated. The State hereby consents to be sued by any person, association of persons, corporation, or city for the purpose of quieting title to the right to oil or gas, or both, in any land, claimed by the State and by such person, association of persons, corporation, or city. Any other person, association of persons, corporation, or city not made a party to such an action but claiming any interest in said oil or gas may intervene in said suit.

All such actions shall be brought and tried in the county where the land or some part thereof is situated.

SEC. 47. Whenever it appears to the commission that wells drilled upon private lands are draining or may drain oil or gas from lands owned by the State, the commission may enter into agreements with the owners or operators of such wells for the payment of compensation to the State for such drainage, in lieu of drilling offset wells upon such State lands.

Article 4. General Provisions Relating to Oil and Gas Leases.

SEC. 51. Permits for prospecting for oil and gas deposits reserved to the State shall not be issued; and permits for prospecting for minerals, other than oil and gas, reserved to the State shall be issued only pursuant to article seven of this act.

SEC. 52. Leases for the extraction and removal of oil and gas deposits may be made by the commission to the highest qualified bidder, as provided in this act. Such a lease shall be for a term of twenty years, with the option of the lessee to continue the term of said lease as to all wells drilling or producing at the expiration of the original term thereof for so long as oil or gas is produced therefrom.

In addition to the royalty provided therein, each bid and each lease shall also provide for an annual rental payment in advance of such sum as the commission shall specify, which rental shall be credited against the royalties, if any, as they accrue for that year.

SEC. 53. All leases of lands containing oil or gas made or issued under this act shall be subject to the condition that the lessee will use all reasonable precautions to prevent waste of oil or gas developed in the land, or the entrance of water through wells drilled to the oil-bearing strata, to the destruction or injury of the oil deposits. All leases shall further provide that the lessee therein shall comply with all valid laws of the United States and of the State of California and with all valid ordinances of cities and counties applicable to the lessee's operations, including, without limitation by reason of the specification thereof, the lessee's compliance with the act of the State of California creating the office of the State Oil and Gas Supervisor, Statutes 1915, page 1404, and all amendments thereto.

SEC. 54. Every oil and gas lease executed under this act shall include such terms, conditions, and provisions as will protect the interests of the State with reference to securing the payment to the State of the proper amount or value of production; the spacing of wells for the purpose of properly offsetting the drainage of oil and gas from State lands by wells drilled and operated on and within privately owned lands; diligence on the part of the lessee in drilling wells to the oil sands and requirements as to depth of such wells for the purpose of reaching the oil sands and producing oil and gas therefrom in commercial quantities; methods of operation and standard requirements for carrying on operations in proper and workmanlike manner; prevention of waste; protection of the safety and health of workmen; liability of the lessee for personal injuries and property damage; security for faithful performance by the lessee, including reasonable provisions for the forfeiture of the lease for violation of any of its covenants or of any of the provisions of this act by the lessee, and the requirement that the lessee shall, at the time of execution of the lease, furnish and thereafter maintain a good and sufficient bond in such sum as may be specified by the commission, in favor of the State, guaranteeing faithful performance by the lessee of the terms, covenants, and conditions of the lease and of the provisions of this act; and such other covenants, conditions, requirements and reservations as may be deemed advisable by the commission in effecting the purpose of this act and not inconsistent with any of its provisions.

SEC. 55. Such lease shall contain a reservation to the commission of the right to restrict by appropriate rules and regulations the spacing of wells and the rate of drilling and production of such wells so as to prevent the waste of oil and gas and promote the maximum economic recovery of oil and gas from, and the conservation of reservoir energy in, each zone or separate underground source of supply of oil or gas covered in whole or in part by leases issued under the provisions of this act. The commission shall issue rules and regulations which may be amended from time to time to effectuate the purpose of this section, and in connection therewith shall restrict the rate of production from any such zone or separate underground source of supply to that provided by Federal or State laws or rules or regulations thereunder, or

by any reasonable conservation or curtailment plan ordered by the commission or agreed to by a majority of the total production from any such zone or separate underground source of supply.

SEC. 56. Rights of way through all State lands may be granted to any lessee by the commission under such regulations as to survey, location, application, and use as may be prescribed by the commission.

SEC. 57. For the purpose of more properly conserving the natural resources of any single oil or gas pool or field, lessees hereunder and their representatives may unite with each other jointly or separately, or jointly or separately with others owning or operating lands not belonging to the State, in collectively adopting and operating under a cooperative or unit plan of development or operation of the pool or field, whenever it is determined by the commission to be necessary or advisable in the public interest, and the commission may, with the consent of the holders of leases involved, establish, alter, change, and revoke any drilling and production requirements of such leases, and may make such regulations with reference to such leases, with like consent on the part of the lessees, in connection with the institution and operation of any such cooperative or unit plan, as the commission deems necessary or proper to secure the proper protection of the interests of the State.

SEC. 58. The commission, upon such conditions as the commission shall prescribe, may approve operating, drilling or development contracts made by one or more lessees holding oil or gas leases on State lands with one or more persons, associations, or corporations, whenever in the discretion of the commission the conservation of natural products or the public convenience and necessity require it, or the interests of the State may be best subserved thereby.

SEC. 59. Each bid (which shall be in the form of a lease prepared in accordance with the provisions of this act) for an oil and gas lease shall be accompanied by a certified or cashier's check of a responsible bank in California payable to the State Treasurer in an amount to be fixed by the commission, which sum shall be deposited as evidence of good faith and except in the case of the successful bidder shall be returned to the bidder. Upon the execution of the lease the amount shall be applied upon the annual rental for the first year and the balance, if any, shall be returned to such lessee. If the successful bidder fails or refuses to execute the lease within fifteen days after the award thereof, the amount of the check shall be forfeited to the State.

Article 5. Oil and Gas Leases on Lands Other Than Tide and Submerged Lands.

SEC. 71. Lands owned by the State, or lands in which the oil and gas deposits are reserved to the State, other than tide and submerged lands, may be leased for the production of oil and gas in accordance with the provisions of this article and of this act in so far as not in conflict with the provisions of this article.

SEC. 72. Whenever it appears to the commission that any such lands probably contain commercially valuable deposits of oil or gas and that it is for the best interests of the State to lease such lands for the production of oil or gas therefrom, the commission shall then offer such lands for lease, as provided in this article.

Sec. 73. The commission may divide the lands within the tract proposed to be leased into parcels of convenient size and shape and shall prepare a form of lease therefor.

Sec. 74. When the form of lease has been prepared by the commission, the commission shall give notice of intention to lease such lands. The notice shall be published for a period of five consecutive days in a newspaper of general circulation in the county in which such lands or the greater portion thereof are situated and shall state the time (which shall not be less than fourteen days after the last date of publication of the notice) and place for receiving and opening bids, a description of the lands, either as a tract or by parcels, and that the form of lease for the purpose of bidding may be procured at the designated office of the commission.

Sec. 75. At the time and place specified in the notice the commission shall publicly open the sealed bids and shall award the lease for each parcel to the highest qualified bidder, unless in the opinion of the commission, the acceptance of the highest bid for any parcel or parcels is not for the best interests of the State, in which event the commission may reject the bids for such parcel or parcels. Thereupon new bids may be called for and the parcel or parcels for which the bids were rejected may be leased as herein provided.

Sec. 76. Lands, other than tide or submerged lands, belonging to the State and dedicated to a public use may be leased by the commission for the production of oil and gas in accordance with the provisions of this article and of this act in so far as not in conflict with this article.

Article 6. Oil and Gas Leases on Tide and Submerged Lands and Beds of Navigable Rivers and Lakes.

Sec. 85. Tide and submerged lands may be leased by the commission for the extraction of oil and gas in accordance with the provisions of this article and of this act in so far as not in conflict with the provisions of this article. No political subdivison of the State or any city or county or any official of either or any of them shall grant or issue any lease, license, easement, privilege, or permit vesting authority in any person to take or extract oil or gas from tide or submerged lands whether filled or unfilled of which the State is the owner or from which the State has the right to extract oil or gas, or both.

Sec. 86. Whenever it appears to the commission that oil or gas deposits are known or believed to be contained in any such lands and may be or are being drained by means of wells upon adjacent lands not owned by the State, the commission shall thereupon be authorized and empowered to lease any such lands, either as a tract or in parcels of such size and shape as the commission shall determine, for the production of oil and gas therefrom, in the manner provided in this article.

Sec. 87. The commission shall prepare a form of lease which shall contain, in addition to other provisions deemed desirable and necessary by the commission, appropriate provisions contained in this act and the following:

(a) Each well drilled pursuant to the terms of such lease shall be drilled only upon filled lands or shall be slant drilled from an

upland or littoral drill site to and into the subsurface of the tide or submerged lands covered by the lease. The derricks, machinery, and any and all other surface structures, equipment, and appliances shall be located only upon filled lands or upon the littoral lands or uplands, and all surface operations shall be conducted therefrom.

(b) Pollution and contamination of the ocean and tidelands and all impairment of and interference with bathing, fishing or navigation in the waters of the ocean or any bay or inlet thereof is prohibited, and no oil, tar, residuary product of oil or any refuse of any kind from any well or works shall be permitted to be deposited on or pass into the waters of the ocean or any bay or inlet thereof.

SEC. 88. When the form of lease has been prepared by the commission, the commission shall give notice of intention to lease such lands. The notice shall be published for a period of five consecutive days in a newspaper of general circulation in the county in which such lands, or the greater portion thereof, are situated and shall state the time (which shall not be less than fourteen days after the last date of publication of the notice) and place for receiving and opening of bids, a description of the lands, either as a tract or by parcels, and that the form of lease for the purpose of bidding may be procured at the designated office of the commission.

SEC. 89. In any notice of intention to lease tide or submerged lands, the commission may include a requirement that each prospective bidder, as a condition precedent to the consideration of his bid and in addition to the other qualifications required by this act, shall present evidence satisfactory to the commission of his present ability to furnish all necessary sites and rights of way for all operations contemplated under the provisions of the proposed lease. In such event the commission shall reject the bids of all bidders who fail to qualify as provided by this section.

SEC. 90. At the time and place specified in the notice the commission shall publicly open the sealed bids and shall award the lease for each parcel to the highest qualified bidder, unless in the opinion of the commission, the acceptance of the highest bid for any parcel or parcels is not for the best interests of the State, in which event the commission may reject the bids for such parcel or parcels. Thereupon new bids may be called for and the parcel or parcels for which the bids were rejected may be leased as herein provided.

SEC. 91. If the Legislature has transferred to any city or county the administration of the trust, whether or not limited, under which such tide or submerged lands are held by the State, the commission, pursuant to the provisions of this act, may enter into agreements upon behalf of the State to compensate any such city or county for the use of surface drilling and operating sites upon such lands from the royalty or revenue to be derived by the State from oil and gas taken from such lands by lessees of the State.

Any such compensation shall include an amount sufficient reasonably to compensate any such city or county for any damage to or interference with the use or uses to which the surface of such lands are being or may be utilized by or upon behalf of such city or county. The consideration to the State in any such agreement shall include the right to a lessee of the State to carry on all operations on any such

tidelands necessary to accomplish the purposes of this act and such terms and conditions as shall be determined by the commission to be in the interests of the State.

The consideration to the State in any such agreement shall also include a compromise, settlement and release of any and all claims and rights which such city or county has or may have against the State arising out of or in connection with the extraction and removal of oil and gas from such lands as provided in this act.

All money paid to any city or county under this act shall be used by it solely in furtherance of the trust under which the administration of tide and submerged lands has been transferred to such city or county and for the purposes expressed in the act so transferring administration of such lands.

Sec. 92. Should it appear to the commission that any person, association of persons, or corporation, has drilled, or is making preparation to drill, wells upon or into tide or submerged lands for the extraction of oil or gas therefrom, whether or not such person, association of persons, or corporation may be acting under purported authority, the commission shall cause an action to be instituted in the name of and upon behalf of the State in a court of appropriate jurisdiction, to enjoin the occupancy and operations upon or in such lands and to demand compensation for injury and damage, if any, to such lands; except that, should the drilling operations be conducted upon or in lands which have been filled and if such operations have been commenced prior to the date of approval by the Governor of this act, the commission, if it appears to be in the interests of the State, may, upon behalf of the State, issue a lease to any such person, association of persons, or corporation in accordance with the provisions of this act in so far as applicable, and upon a royalty basis, retrospective and prospective, which appears reasonable and just in the circumstances to the lessee and the State.

Sec. 93. The beds of navigable rivers and lakes belonging to the State may be leased by the commission for the production of oil and gas, subject to the same limitations and conditions as are imposed upon tide and submerged lands by this article, and in accordance with the provisions of this act in so far as not in conflict with this article.

Sec. 94. Nothing in this act shall be construed to limit the effect of any grant of tide or submerged lands heretofore made to any city, county or other political subdivision, nor in any manner to prejudice whatever claim the State, on the one hand, or such city, county or political subdivision, on the other, may have in or to the right to extract or authorize the extraction of oil or gas or other minerals underlying such lands.

Article 7. Minerals Other Than Oil and Gas.

Sec. 111. Prospecting permits and leases for the extraction and removal of minerals other than oil and gas from lands belonging to the State, other than tide or submerged lands, may be issued as provided in this article and in this act in so far as not in conflict with the provisions of this article.

Sec. 112. The commission shall issue a prospecting permit, under such rules and regulations as it may prescribe, to any qualified appli-

cant, upon the payment to the commission of one dollar per acre for each acre in area embraced within the boundaries of the lands described in the permit, but no permit shall be issued for any lands which have been classified by the commission prior to such application as containing commercially valuable mineral deposits.

Such prospecting permit shall give to the permittee the exclusive right for a period not exceeding two years to prospect for minerals other than oil and gas upon not to exceed one hundred sixty acres of land wherein such mineral deposits belong to the State.

The commission may, in its discretion, extend the term of any permit for a period not exceeding one year, but the term of any such permit, including extensions, shall be limited to a total of three years.

Sec. 113. If the applicant erects upon the land for which a permit is sought a monument not less than four feet high, at some conspicuous place thereon, and posts written notice on or near the monument, stating that an application for a permit will be made within thirty days after the date of posting the notice, giving the name of the applicant, the date of the notice, and such a general description of the land to be covered by the permit by reference to courses and distances from the monument or from such other natural objects or permanent monuments, or both, as will reasonably identify the land, stating the amount thereof in acres, and if the applicant records a copy of the notice, within two days after the posting thereof, in the county recorder's office of the county in which the land is situated, he shall be entitled to a preferential right over others to a permit for the land so identified for a period of thirty days following such marking and posting.

Sec. 114. In case of an application for a permit or lease covering mineral deposits reserved to the State in lands sold by the State subject to such reservation by any one other than the owner of such lands, such owner shall have six months within which to file an application for a permit or lease, but if such owner fails to comply with the requirements of this act and the rules and regulations made in pursuance hereof, his preferential rights shall thereupon cease and terminate, and the original applicant shall be permitted to proceed with his application.

Sec. 115. The applicant shall, within ninety days after receiving a permit, mark each of the corners of the tract described in the permit upon the ground with substantial monuments, so that the boundaries can be readily traced upon the ground and shall post in a conspicuous place upon the lands a notice that such permit has been granted and a description of the lands covered thereby.

Sec. 116. Upon establishing to the satisfaction of the commission that commercially valuable deposits of minerals have been discovered within the limits of any permit, the permittee shall be entitled to a lease for not more than forty acres of the land embraced in the prospecting permit, if there be that number of acres within the permit. The area to be selected by the permittee shall be in compact form, and if surveyed to be described by the legal subdivisions of the public land surveys; if unsurveyed, to be surveyed by the commission at the expense of the applicant for the lease, in accordance with rules and regulations to be prescribed by the commission, and the lands leased shall be conformed to and taken in accordance with the legal sub-

divisions of such surveys. Such lease shall be upon a royalty, as specified by the commission in the permit, and the annual payment in advance of a rental of one dollar per acre, the rental paid for any one year to be credited against the royalties as they accrue for that year.

Sec. 117. Until the permittee applies for a lease as to that portion of the area described in the permit herein provided, he shall pay to the State twenty per cent of the gross value of the minerals secured by him from the lands embraced within his permit and sold or othewise disposed of or held by him for sale or other disposition.

Sec. 118. All deposits of minerals, other than oil and gas, in lands belonging to the State which have been classified by the commission as lands containing commercially valuable mineral deposits and all deposits of such minerals within lands embraced within a prospecting permit and not subject to preferential lease to the permittee, may be leased by the commission to the highest responsible bidder by competitive bidding under general regulations to qualified applicants in areas not exceeding eighty acres and in tracts which shall not exceed in length two and one-half times the width, in such form as the commission deems to be to the best interest of the State. In addition to the royalty provided therein, each bid and each lease shall also provide for an annual rental payment in advance of such sum as the commission shall specify, which rental shall be credited against the royalties, if any, as they accrue for that year.

Sec. 119. Leases under this article shall be for terms of twenty years with the preferential right in the lessee to renew the lease for successive periods of ten years upon such reasonable terms and conditions as may be prescribed by the commission.

Sec. 120. The commission shall prescribe such additional terms, covenants and conditions, consistent with the provisions of this act, of permits and leases issued under this article as will in its opinion effectually protect the interests of the State in the mineral deposits reserved to it by this act.

Article 8. Miscellaneous Provisions.

Sec. 130. All moneys and remittances received by the State pursuant to this act shall be deposited in the State treasury to the credit of the "State Lands Act Fund," which fund is hereby created. There shall also be transferred to and deposited in said fund the balance of moneys in any appropriation or special fund in the State treasury now remaining or made available by law for the support of the Division of State Lands in the Department of Finance or for the administration of the statutes and laws the administration of which is transferred to the commission by this act. The moneys in said fund are hereby appropriated as follows:

(a) There shall first be transferred to the "school fund" all rents, bonuses, royalties, and profits accruing from the use of State school land.

(b) The moneys transferred to the State lands act fund from existing appropriations and special funds, as provided by this section, shall be expended by the commission only in accordance with law for the support of the Division of State Lands in the Department of Finance and for carrying on the works or performing the duties for which the appropriations were made or the special funds created.

(c) The remainder of the moneys shall be used by the commission, with the approval of the Director of Finance and the consent of the Governor, to carry out the provisions of this act, including the acquisition of real property or interests therein, the purchase of materials and supplies, and the conducting of operations by the State as provided herein, the payment by the State of such sums as may be provided pursuant to agreements or contracts authorized herein, the payment of the necessary expenses of the commission, and the payment of refunds.

(d) Any remaining balance shall be transferred to the general fund on order of the commission, except thirty per cent thereof, which shall be transferred to the "State park maintenance and acquisition fund," which fund is hereby created, to be expended in the manner hereafter provided by law.

SEC. 131. The following acts, together with all amendments thereof, are hereby repealed, but such repeal shall not affect any existing vested rights thereunder or any permit, lease, or agreement entered into under any provision thereof, nor shall it affect the rights or duties of any purchaser of State lands sold prior to the effective date of this act.

"An act to reserve all minerals in State lands; to provide for examination, classification and report on the mineral and other character of State lands; to provide for the granting of permits and leases to prospect for and take any such minerals; to provide for the rents and royalties to be paid, and granting certain preference rights; to provide for the making of rules, regulations and contracts necessary to carry out the purposes of this act; and repealing acts or parts of acts in conflict herewith; providing for an appropriation to defray the cost of administering this act," approved May 25, 1921 (Chapter 303, Statutes of 1921).

"An act to authorize the leasing of certain lands belonging to the State of California containing oil, gas, or other hydrocarbon deposits and providing for the disposition of the moneys received under said leases, and creating a commission to carry out the provisions of this act," approved May 25, 1923 (Chapter 227, Statutes of 1923).

SEC. 132. This act shall not be construed as repealing or otherwise affecting an act entitled "An act relating to lakes and streams, the waters of which contain minerals in commercial quantities; withdrawing State lands within the meander lines thereof from sale; prescribing conditions for taking such minerals from said waters and lands, and providing for the leasing of lands uncovered by the recession of the waters of such lakes and streams," approved April 27, 1911 (Chapter 612, Statues of 1911).

SEC. 133. If any clause, sentence, paragraph or part of this act shall, for any reason, be adjudged by any court of competent jurisdiction to be invalid, such judgment shall not affect, impair, or invalidate the remainder of this act, but shall be confined in its operation to the clause, sentence, paragraph or part thereof directly involved in the controversy in which such judgment shall have been rendered.

SEC. 134. All acts or parts of acts in conflict with the provisions of this act are hereby repealed.

NEW AMENDMENT TO THE 'CAMINETTI ACT,' 1938.

An act to amend section 23 of the Act to create the California Débris Commission, as amended.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 23 of the Act approved March 1, 1893, entitled "An Act to create the California Débris Commission and regulate hydraulic mining in the State of California", as amended by the Act approved June 19, 1934, is hereby further amended by adding at the end thereof the following: "The Secretary of War is authorized to enter into contracts to supply storage for water and use of outlet facilities from débris storage reservoirs, for domestic and irrigation purposes and power development upon such conditions of delivery, use, and payment as he may approve: *Provided,* That the moneys received from such contracts shall be deposited to the credit of the reservoir project from which the water is supplied, and the total capital cost of said reservoir, which is to be repaid by tax on mining operations as herein provided, shall be reduced in the amount so received".

Approved, June 25, 1938.

ADMINISTRATIVE

Walter W. Bradley, State Mineralogist

Personnel.

The State Personnel Board having approved the addition of a "geological clerk" to the staff of the San Francisco headquarters office, and also the change of classification of the clerk in the Sacramento district office from intermediate stenographer clerk to that of geological clerk, the following appointments to those positions are here recorded:

Miss Elizabeth L. Egenhoff, of Berkeley, a graduate in geology of the University of California, as geological clerk and assistant to the chief geologist of the Division of Mines.

Miss Antoinette Ryan, of San Francisco, a graduate in geology of Stanford University, as geological clerk and assistant to the district mining engineer in the Sacramento office.

New Publications.

California Journal of Mines and Geology, April, 1938, being Chapter 2 of State Mineralogist's Report XXXIV. This chapter contains: "Gold Dredging in Shasta, Siskiyou and Trinity counties"; "Geology of the Central Santa Monica Mountains, Los Angeles County." "Marketing Mica"; also advance statistical data on the production in 1937 of borates, cement, chromite, dolomite feldspar, gypsum, iron ore, magnesium salts, pumice and volcanic ash, silica, slate, soapstone and talc; also a list of mineral specimens recently added to the museum display.

Commercial Mineral Notes (Nos. 181-183, inc.). May, June, July, 1938, respectively. These 'Notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to four pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

Tabulations are presented herein showing the complete totals for all substances produced in California during the year 1937, grouped by substances and by counties. The complete detailed annual report on the mineral production of California for 1937 will be available later as Bulletin 116 of the State Division of Mines.

SUMMARY—1937

The total value of the mineral output of California for the year 1937 was $361,515,951, being an increase of $33,711,683 over the total of 1936 which was $327,804,268. There were fifty-seven different mineral substances, exclusive of a segregation of the various stones grouped under gems; and all fifty-eight counties of the state contributed to the list.

As revealed by the data following, the salient features of 1937 compared with the previous year were: All groups such as fuels, metals, industrial minerals, and salines, with the exception of the structural materials, showed an increase in total value. Of the individual mineral products, petroleum showed the greatest increase in value and output, followed in turn by gold, natural gas, brick and hollow building tile, silver, tungsten ore, potash, mineral water, copper, miscellaneous stone, borates, quicksilver, limestone, diatomite, and others; while those showing a decrease in amount and value were cement, granite, magnesium salts, platinum, bituminous rock, pyrite, pumice and volcanic ash, salt, and slate.

Of the fuels, petroleum showed an increase in value of $26,178,687, and an increase in amount of from 214,776,227 barrels to 238,558,562 barrels of crude oil. The average price received for all grades of crude oil was an increase over that received in 1936 although there was no change in the price of crude from June, 1936. Natural gas showed an increase in value and amount from 298,922,708 M cu. ft. worth $18,585,970 to 323,883,714 M cu. ft. worth $19,859,865.

Of the metals, the gold output increased from 1,077,442 fine ounces to 1,174,578 fine ounces; and in value from $37,710,470 to $41,110,230. Silver increased from 2,103,799 fine ounces worth $1,629,392 to 2,888,-265 fine ounces worth $2,234,073; copper from 9,991,799 lbs. worth $919,245, to 10,512,500 lbs. worth $1,272,013, with all other metals showing an increase in output except iron ore and the platinum metals, which showed a slight decrease.

Of the structural materials, miscellaneous stone increased in value from $16,578,238 to $16,917,683 with also lime, marble, magnesite, and sandstone showing increased total values. Cement declined in amount and value from 13,300,188 barrels valued at $18,314,589, to 12,072,062 barrels worth $16,546,229, with all other substances in the group showing lower total values than the previous year.

In the industrial group the total value increased from $5,236,534 to $6,159,918, and with most of the important mineral products therein showing increases, noteworthy were diatomite, limestone, mineral water, pottery clay, gypsum, silica, talc and soapstone. Slight decreases were registered by feldspar, pumice and volcanic ash, and pyrite.

The total value of the saline group increased from $12,416,349 to $13,216,270, with all the larger products showing an increased value with the exception of salt and magnesium salts.

Distribution of the 1937 output of California by substances is shown in the following tabulation:

Substance	Amount	Value	Number of properties
Bentonite	8,425 tons	$140,261	6
Borates	326,099 tons	6,206,619	5
Brick and hollow building tile		3,083,902	43
Cement	12,072,062 bbls.	16,546,229	10
Chromite	1,918 tons	20,830	7
Clay, pottery	354,669 tons	705,200	57
Copper	10,512,500 lbs.	1,272,013	([5])
Dolomite	12,371 tons	24,603	4
Feldspar	2,686 tons	10,930	3
Gems		2,075	5
Gold	1,174,578 fine ozs.	41,110,230	1,751
Granite		207,738	17
Gypsum	186,160 tons	384,431	5
Iron ore	5,490 tons	29,340	4
Lead	2,402,110 lbs.	141,724	([5])
Lime	69,532 tons	681,277	25
Limestone	351,755 tons	830,562	
Magnesium salts	7,733,918 lbs.	313,669	3
Marble		23,667	6
Mineral water	18,309,729 gals.	1,130,810	38
Natural gas	323,883,714 M cu. ft.	19,859,865	([2])
Petroleum	238,558,562 bbls.	237,845,872	
Platinum	530 ozs.	23,704	([5])
Pumice and volcanic ash	10,392 tons	79,005	17
Quicksilver	9,995 flasks	837,789	65
Salt	370,431 tons	1,044,325	12
Sandstone		15,680	6
Silver	2,888,265 fine ozs.	2,234,073	([5])
Silica	84,313 tons	348,987	5
Slate		32,572	7
Soapstone and talc	29,657 tons	347,772	9
Soda	153,685 tons	1,461,057	4
Stone, miscellaneous	([3])	16,917,683	382
Tungsten	611 tons	782,187	8
Zinc	39,643 lbs.	2,577	([5])
Unapportioned[4]		6,813,693	([4])
Total value		$361,515,951	

[1] There were 913 lode mines and 838 placer mines, not including snipers, prospectors, and various individuals who sold small lots.

[2] There was an average of 12,954 producing wells.

[3] Includes macadam, crushed rock, ballast, rubble, riprap, sand and gravel.

[4] Includes barite (2), bituminous rock (2), bromine (2), calcium chloride (2), carbon dioxide (2), coal (3), diatomite (6), fluorspar (1,) iodine (2), magnesite (2), mica (2), mineral paint (3), potash (1), pyrite (1), sillimanite group (2), tube mill pebbles (1), sulphur (1), zircon (1).

[5] Included with gold.

Distribution by counties of the 1937 output for California, by substances, is shown in the following tabulation:

County	Value	Number of mineral products
Alameda	$2,476,302	7
Alpine	22,791	5
Amador	3,917,866	9
Butte	1,798,992	11
Calaveras	3,279,250	12
Colusa	9,424	3
Contra Costa	1,867,309	8
Del Norte	30,647	4
El Dorado	2,607,972	13
Fresno	41,178,791	15
Glenn	136,368	2
Humboldt	100,715	7
Imperial	677,401	14
Inyo	1,439,009	18
Kern	74,162,134	16
Kings	11,008,597	3
Lake	392,585	4
Lassen	86,240	5
Los Angeles	100,337,635	22
Madera	133,165	7
Marin	300,204	4
Mariposa	1,270,774	10
Mendocino	114,705	2
Merced	2,535,126	6
Modoc	36,990	6
Mono	804,925	7
Monterey	262,651	10
Napa	356,146	9
Nevada	11,385,056	9
Orange	22,659,380	7
Placer	1,754,040	12
Plumas	2,354,957	7
Riverside	4,057,127	13
Sacramento	4,230,689	7
San Benito	504,510	6
San Bernardino	16,012,330	26
San Diego	591,479	14
San Francisco	41,825	2
San Joaquin	706,620	6
San Luis Obispo	323,691	13
San Mateo	2,310,784	6
Santa Barbara	10,709,056	10
Santa Clara	722,903	9
Santa Cruz	2,074,463	6
Shasta	2,199,423	8
Sierra	974,680	6
Siskiyou	1,200,351	11
Solano	145,567	4
Sonoma	273,063	8
Stanislaus	940,030	5
Sutter	22,959	3
Tehama	65,193	2
Trinity	721,290	6
Tulare	314,952	10
Tuolumne	1,012,180	10
Ventura	19,230,720	8
Yolo	44,171	3
Yuba	2,587,748	6
Total value	$361,515,951	

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20855 MOLYBDENITE, MoS, molybdenum sulphide. From near Questa, New Mexico.
Donor: V. S. Barber. May, 1938.

20856 Franciscan SANDSTONE. From diamond drill core on west end of San Francisco-Oakland Bay Bridge.
Donor: Jack Zari. May, 1938.

20857 TURQUOISE. From Copper Basin Turquoise Mine of the American Gem Company, eight miles southwest of Battle Mountain, Nevada.
Donor: D. J. Wilson, Mgr. May, 1938.

20858 BARRANDITE, (Al, Fe) $PO_4.2H_2O$, a hydrous phosphate of aluminum and iron. From Gold Metals Mine, Manhattan, Nevada.
Donor: E. Clinton. June, 1938.

20859 CHRYSOCOLLA, $CuSiO_3.2H_2O$, a hydrous copper silicate. From Tumco Mining District, in Cargo Muchacho Mountains, Imperial County, California.
Donor: Thomas M. Smith. June, 1938.

20860 AUGELITE, $2Al_2O_3.P_2O_5.3H_2O$, a hydrous aluminum phosphate. From the White Mountains, Mono County, California.
Donor: C. D. Woodhouse. July, 1938.

20861 WOODHOUSEITE. $2CaO.3Al_2O_3.P_2O_5.2SO_3.6H_2O$, a hydrous aluminum calcium sulphate-phosphate. From the White Mountains, Mono County, California.
Donor: C. D. Woodhouse. July, 1938.

20862 COLORADOITE and CHALCOPYRITE. From Great Boulder, A. M., Kalgoorlie, Western Australia.
Donor: C. D. Woodhouse. July, 1938.

20863 CALAVERITE with chalcopyrite and tetrahedrite. From Boulder Perseverance, A. M., Kalgoorlie, Western Australia.
Donor: C. D. Woodhouse. July, 1938.

20864 CALAVERITE and COLORADOITE. From Boulder Perseverance, A. M., Kalgoorlie, Western Australia.
Donor: C. D. Woodhouse. July, 1938.

20865 CALAVERITE and COLORADOITE, with chalcopyrite and specks of free gold. From Boulder Perseverance, A. M., Kalgoorlie, Western Australia.
Donor: C. D. Woodhouse. July, 1938.

20866 DURDENITE, $Fe_2(TeO_3)_3.4H_2O$, hydrous ferric tellurite. From Goldfield, Nevada.
Donor: Hatfield Goudey. July, 1938.

20867 JAROSITE, $K_2Fe_6(SO_4)_4(OH)_{12}$, a hydrous potassium and iron sulphate. From Goldfield, Nevada.
Donor: Hatfield Goudey. July, 1938.

20868 REALGAR, AsS, arsenic mono sulphide. From Goldfield, Nevada.
Donor: Hatfield Goudey. July, 1938.

20869 REALGAR, AsS; Stibnite, Sb_2S_3. From Goldfield, Nevada.
Donor: Hatfield Goudey. July, 1938.

20870 TOURMALINE. From near the Drummond Mine, Placer County, California.
Donor: W. K. Reed. July, 1938.

20871 ALUNOGEN, $(Al_2SO_4)_3.16H_2O$. Locality not stated.
Donor: Nicholas Baxter. July, 1938.

20872 DIALLAGE, a variety of pyroxene. From Happy Camp, Siskiyou County, California.
Donor: John H. Esselink. July, 1938.

20873 CALCITE (fluorescent). From Brewster County, Texas.
Donor: John H. Esselink. July, 1938.

20874 FLUORITE, CaF_2, after aragonite. From Funeral Mountains, Inyo County, California.
Donor: John H. Esselink. July, 1938.

20875 Iridescent LIMONITE, a hydrous iron oxide. From Swail Mountains, north of Elko, in Elko County, Nevada.
Donor: C. Fischer. July, 1938.

20876 Core from depth of 14,583 ft. Drilling stopped at 15,004 ft. Well later producing between 13,092 and 13,175 ft. From K. C. L. Well A No. 2, near Wasco, Kern County, California.
Donor: Continental Oil Company. July, 1938.

20877 CLINKER formed from the burning of coal seams near the surface. The coal was ignited by prairie fires usually started by lightning. From McKenzie County, North Dakota.
Donor: S. T. Westdal. July, 1938.

20878 Small THRUST FAULT in a Gneiss. Displacement and overlapping of the light colored bands are very marked. From Boulder County, Colorado. Donor: S. B. Fiske. July, 1938.

20879 MALACHITE, copper carbonate—pseudomorph after azurite, from Tsumeb, South West Africa. Exchange. August, 1938.

20880 CHROMITE (black) with UVAROVITE (green) and KAMMERERITE (peach). From west of King City, Monterey County, California.
Donor: C. E. Dolbear. August, 1938.

LABORATORY

GEORGE L. GARY, Acting Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one "Minerals of California," by Adolf Pabst, was published this year by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

No. 1. Bulletin 113, page 7, last line: 1827 should be *1927*.

No. 2. White grossularite, a calcium-aluminum garnet and brownish-red almandite, an iron-aluminum garnet occurs near the headwaters of the San Benito River in San Benito County.

LIBRARY

John C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

B 895-C Geophysical Abstracts 90, July-Sept., 1937.

Professional Papers:

189 A Species and Genera of Tertiary Noetinae.
189 C Pliocene Diatoms from the Kettleman Hills, Calif.
190 Lower Pliocene Molluska and Echinoids from the Los Angeles Basin, Calif.

Topographic Maps:

Beartrap, Calif.
Beartrap Canyon, Calif., Los Angeles Co.
Bidwell Bar.
Black Mountain, Los Angeles Co.
Camulos.
Colfax.
Damsites, sheets, A-B-C-D-E and F.
Devore, San Bernardino Co.
Gorman.
Kettleman City, Kings Co.
Liebre.
Lethent.
Lost Hills.
Lassen National Forest.
Manzaneta Quad. Los Angeles Co.
Medford, Ore-Calif.
Pacheco Pass Quad.
Plan and Profile of Sacramento River, Calif.
Quail.
Red Bluff.
Redding, Shasta Co.
San Bernardino Quad.
Searles Lake Quad.
Sebastopol.
Ventura.
Yosemite.
Mariposa Quad.

Vegetation Types of California.

Elsinore Quad.
Yosemite National Park.

U. S. Bureau of Mines

Report of Investigations:

3397 Flotation and Agglomerate Concentration of Nonmetallic Minerals. By Oliver C. Ralston.
3399 Bureau of Mines Apparatus for Determining The Dew Point of Gases under Pressure. By W. M. Deaton and E. M. Frost, Jr.
3400 Progress Reports—Metallurgical Division 24.
Mineral Physics Studies.
3401 Efficiency of Impingers for Collecting Lead Dusts and Fumes. By J. B. Littlefield, Florence L. Freicht and H. H. Schrenk.
3402 Flow Characteristics, Composition, and Some Liquid-Phase Properties of Hydrocarbon Fluids from a "Combination" Well. By C. K. Eilerts and M. A. Schellhardt.
3407 Earth Vibrations Caused by Mine Blasting Progress Report 2. By J. R. Thoenen and Stephen L. Windes.

Information Circulars:

7008 Verde Antique. By Oliver Bowles and Florence Davidson.
7009 Dewatering and Drying of Coal. By James R. Cudworth and Ellis S. Hertzog.

7010 Advanced Mine Rescue Training Course of the Bureau of Mines. By J. J. Forbes.
7012 Milling Methods and Costs of the Cardinal Gold Mining Co., Bishop Creek, Calif. By Walter B. Lenhart.
7013 Power-Shovel and Dragline Placer Mining. By E. D. Gardner and Paul T. Allsman.
7014 Multiple-Shift Mechanical Mining in Some Bituminous Coal Mines. Progress Report 1. By A. L. Toenges and R. L. Anderson.
7015 Gold Mining and Milling in Northeastern Oregon. By S. H. Lorain.
7016 Smoke Abatement. Selections from Papers by O. P. Hood. By J. F. Barkley.
7019 State Regulations Pertaining to the use of Internal-Combustion Engines in Coal and Metal Mines and in Tunnels. By L. C. Illsley and E. J. Gleim.
7020 Reducing cost of Workmen's Compensation in the Mining Industry. By D. Harrington.
7024 Mining & Milling Methods and Costs of the Golden Anchor Mining Co., Burgdorf, Idaho. By S. H. Lorain and W. Buford Davis.
7025 Some Observations on the Causes, Behavior, and Control of Fires in Steep-Pitch Anthracite Mines. By G. E. McElroy.
7026 A Technique for use of the Impinger Method. By Carlton E. Brown and H. H. Schrenk.
7027 One Hundred-Percent First-Aid Training, Peabody Coal Co., Taylorville, Christian County, Ill. By A. U. Miller.
B. 402. Crushing and Grinding.

Books

The American Philosophical Society Year Book, 1937.
Petroleum and Natural Gas Bibliography, Hardwicke.
Feasibility of Establishing an Iron and Steel Industry in the Lower Columbia River Area Using Electric Pig Iron Furnaces. By Raymond M. Miller. In two volumes, Sections 1 to 7.
Feasibility of Electrolytic Zinc and Cadmium Production in the Lower Columbia River Area. By Raymond M. Miller.
Ground Water. By C. F. Tolman.

The following donation of books was received from W. E. Plank:

California State Mining Bureau Bulletin No. 1.
Proceedings of the 6th Annual Convention of the California Miners Association.
Proceedings of the 7th Annual Convention of the California Miners Association.
Proceedings of the 8th Annual Convention of the California Miners Association.
Mine Development, the Basis of Prospecting. By Almarin B. Paul.
Biennial Message of Gov. R. W. Waterman, 1889.
Total Solar Eclipse, Dec. 1889, etc., Lick Observatory.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.

Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers. New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.

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Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.

Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

ADDENDA

Supplemental Data on El Dorado County Mines (see pp. 206-280 *ante*)

Big Canyon Dredge (Drag-line). On Big Canyon Creek 4 miles east of Latrobe. Geo. King and associates are operating a drag-line with 3-cu. yd. bucket, working a crew of 11 men two shifts and handling over 2000 yards daily. The gravel is yielding a very satisfactory return and it is believed that about two million cubic yards remain to be mined.

Bucks Bar (see ante). Being worked late in 1938 by Horseshoe Mining Company, with a drag-line outfit.

Concordia, Champion, Eden Consolidated and other claims formerly belonging to Thomas Alderson are one mile east of Diamond Springs on the Pleasant Valley road. They occupy part of the Mariposa clay slates on the Mother Lode.

Old workings, run 35 years ago or earlier, include the following:

Champion claim	Open cut 100 ft. long
Cincinnati claim	Open cut 200 ft. long
Concordia claim	Shaft 50 ft.; open cut 100 ft.
Rattler claim	Adit 600 ft., giving 200 ft. depth

Recently Alderson Gee has been doing some work on the Concordia, apparently the first activity on the group for a long time. He reports that in 1933 he sank a new shaft 50 ft. deep 30 ft. south of the old shaft and had 13 tons of ore milled which yielded $11 a ton.

The vein there is reported to average 3 ft. wide but swells and pinches both on the dip and strike. The three veins common to the Mother Lode, called east, middle and west veins are found on these claims and show widths up to 10 ft. On the Rattler claim, Gee states he has a prospect which assays high in gold. The veins and the slate enclosing them, have been turned from the usual northwest course by a quartz porphyrite intrusive, and strike east of north.

Dayton Consolidated Mines Company, a Nevada corporation, Virginia City, Nevada, spent some time prospecting land on three sides of the Black Oak Mine in Garden Valley district. The holdings in which they were interested were the Davey land on the north, the Clark land on the east or hanging wall side and the Davenport land on the strike to the southeast. See under Black Oak Mine, to the owners of which the Dayton company is reported to have transferred their options in January, 1938.

Eagle King Mine. This old mine, 2½ miles northwest of Grizzly Flat, was worked before 1900 by adits, of which the principal one was over 1450 ft. long, with a winze reported 60 ft. deep. It had a 10-stamp mill which was used from 1895 to 1898 inclusive, and during that period over $20,000 was produced.

In June, 1938, B. N. Jackson and E. P. Hurt began work on the property to reopen the adit and sample the veins.

The mine is near the border of the granodiorite with the Calaveras (Carboniferous) formation on the east.

E. R. Skinner Ranch. It is $3\frac{1}{2}$ miles west of Rescue P. O. near the Green Valley road. Henry J. Snyder and Harry Marsh of Grass Valley had this property under lease late in 1937 and early in 1938. There are some good-sized quartz veins which have produced pocket gold, but the lessees were unable to find an ore shoot of any size. After several months work they found a "rich spot" which yielded \$10,000 from 36 tons of ore. After removing this they gave up the lease.

In May, 1938, Gilbert Chisholm formed Pilot Knob Mining Company to work the soft, oxidized surface material. A 5-ft. Chilean type mill, gold trap, Wilfley table and corduroy tables were installed and in July, 1938, twelve men were mining and milling from 12 tons to 25 tons of rock daily. Besides the open cut from which ore was being hauled to the mill, a shaft had reached a depth of 75 ft.

Oro Fino No. 1 and No. 2 Claims are a mile south of Garden Valley in a narrow strip of amphibolite schist lying in Mariposa slate. At intervals for 12 years past they have been worked in a limited way by various lessees, with a small production of gold. In August, 1938, John S. Dichesare had the lease and was planning to mill some ore after cleaning out 200 ft. of an adit 250 ft. long. The other workings include a shaft 70 ft. deep and a small open pit.

The vein is from 2 ft. to 12 ft. thick and has been stoped for a length of 20 ft. to 30 ft. to the 70-ft. level. Ore is reported to assay \$8 to \$10 a ton. There is no mill on the claims and ore in the past has been crushed at the Frog Pond mill, a short distance north. Samuel Collins, Garden Valley, owns both the Oro Fino and Frog Pond mines.

Spanish Oak Prospect. Lot 40 in the N$\frac{1}{2}$ sec. 12, T. 11 N., R. 10 E., near the road from Poor's Store to Spanish Flat. Late in 1938, Russell Wilson, operator of the Black Oak Mine, began a shaft here and found a promising showing of gold. John Quiggle, the owner for many years, had previously prospected the land in a small way.

Ore is already being hauled from this property to the mill at the Rozecrans mine.

Tipton Hill Placer Mine. In sec. 3, T. 12 N., R. 11 E., above Rock Creek, into which it drains. This is an old mine worked successively by hydraulicking and drifting. It occupies a bend on a section of white quartz channel, with bedrock 80 ft. below the surface in some of the old workings. The hydraulic pit was opened on the outside of the bend. Adits were run and 4 prospect shafts were sunk. It is said that the slope of bedrock in these indicate the deepest ground has not been opened, and prospecting during the past 7 years has been directed toward opening this. The total amount of old drifting which was 750 ft. 35 years ago, is uncertain. Lately, 270 ft. of adit, largely reclaimed old workings, has been opened, but the objective has not been reached. Frank Irish, Georgetown, is the owner. Ernest Lowell, H. B. Knapp and others have been working under lease. Water costs 25 cents a miner's inch from the Georgetown ditch.

SLATE

Although the black roofing slate deposits of El Dorado County are extensive and have supplied considerable satisfactory material in the past, they are not covered in detail in this report as they have been fully described in our past publications, the last of which was published in October, 1926. Since that time, the only development of importance in slate in the county has been the work of

Pacific Minerals Company, Limited, who have a slate mine and crushing plant at Chili Bar bridge on the south side of South Fork of American River 3½ miles north of Placerville. Started several years ago by Commercial Minerals Company, a business employing from 10 to 20 men has been built up.

Slate is mined underground by wide drifts in order to obtain clean rock. It is crushed in a hammer mill and screened. The larger part of the product is sold in the form of granules which are used for coating prepared roofing. The undersize material is suitable for use as a filler.

The black slate of the Mariposa beds crosses the country from north to south, varying in width from 1 mile to 3 miles. Roofing slate of good blue-black color, of good strength and not fading or softening appreciably in 40 years of use, has come from quarries between Placerville and Kelsey, but largely from *Eureka Slate Quarry,* 1 mile west of Kelsey. This quarry was equipped with hoisting engines, slate saws, and planers and turned out a variety of products for interior use such as sink and table tops, tiling, mantles and electric switchboards. This quarry has been closed for over 20 years.

Other deposits on which some work has been done are

Name of Slate Quarry	Location
Buck	adjoins Chili Bar quarry
California-Bangor	secs. 3, 10, 11, 14 T. 11 N., R. 10. E.
California	secs. 23, 25 T. 11 N., R. 10 E.
Chili Bar	just west of Chili Bar bridge
El Dorado	secs. 6, 7, T. 10 N., R. 11 E.
El Dorado Slate Products Co.	see El Dorado and California
Losh	sec. 25, T. 11 N., R. 10 E.

Bibl: Cal. State Min. Bur. Bull. 38, pp. 150-152; State Mineralogist's Reports, VIII, pp. 199-200; IX, pp. 282-283; XII, pp. 400-402; XV, pp. 306-308; XXII, pp. 446-450.

TUNGSTEN

In June, 1930, B. F. Magee and Lee Wolf found scheelite in sec. 4, T. 11 N., R. 11 E. and located 8 claims calling the group "Comeback Consolidated." In 1931 and 1932 some concentrate was made and sold but no output has been reported since. Besides the old adit that had been already run, a little prospecting has been done since and the property has been examined by several engineers, but disputes regarding ownership are said to have delayed further work.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of California Journal of Mines and Geology, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of California Journal of Mines and Geology.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print. Price Postpaid

**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks ---- ----

**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks ---- ----

**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks ---- ----

**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks ---- ----

**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks ---- ----

Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks ---- $0.75

Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. ---- .75

**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr. ---- ----

**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr. ---- ----

**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr. ---- ----

**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 ilustrations, 10 maps. William Irelan, Jr. ---- ----

Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps William Irelan, Jr. ---- 1.50

**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford ---- ----

**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford ---- ----

Chapters of the State Mineralogist's Report, Biennial Period, 1913-1914, Fletcher Hamilton:

**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper ---- ----

Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper ---- .75

**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper ---- ----

**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper ---- ----

**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper ---- ----

**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper ---- ----

**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915:
A General report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth ---- ----

Chapters of the State Mineralogist's Report, Biennial Period, 1915-1916. Fletcher Hamilton:

**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176, pp., paper ---- ----

Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper ---- .75

Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper ---- .75

Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper ---- .75

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**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper	$1.00
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Mines and Mineral Resources of Sierra County, 144 pp., paper	.75
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	2.50
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, ** November, December, 1922	.40
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	.40
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy	.40
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.40
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.40
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**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California, Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.40
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Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
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Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
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April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island	.40
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931	.40
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.40
**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	----
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)	.25
July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a Part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist	.75

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July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming. Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543	1.00
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
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Chapters of Report XXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
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July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights	.60
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Chapters of Report XXXII, 1936 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Gold Mines of Placer County, including Drag-line Dredges. Geologic Report on Borax Lake, California	.60
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July. Mines and Mineral Resources of Calaveras County. Mining in California by Power Shovel. Assessment Work on Mining Claims Within Withdrawn Areas. Joshua Tree National Monument. Cost	

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of Producing Quicksilver at a California Mine in 1931-1932. The Age of Mineral Utilization-- $0.60
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Chapters of Report XXXIII, 1937 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:
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April. Mineral Resources of Plumas County (with Geologic Map). List of preferred mineral names. New Placer Mining Debris Law .60
July. Mineral Resources of Los Angeles County (with map showing principal Mines and Oil Fields.) Geology and mineral deposits of the Western San Gabriel Mountains, Los Angeles County------ .60
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Chapters of Report XXXIV, 1938 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:
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April. Gold dredging in Shasta, Siskiyou and Trinity Counties; Geology of the Central Santa Monica Mountains; Marketing Mica--------- .60
July. El Dorado County, Mineral High-Lights of California; Strategic Minerals of California; Cyanide Treatment of Gossan at Mountain Copper Co.; Submarine Canyons off the California Coast---------- .60
Subscription, $2.00 postpaid in advance (by calendar year only).
Chapters of State Oil and Gas Supervisor's Report:
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume) --- Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:
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BULLETINS

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**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of California Fossils, by J. G. Cooper, 1894. 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means, 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms, 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----

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**Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	----
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 29. Mineral Production of California for Sixteen years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by W . Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 48. Mineral Production of California for Twenty Years, by Charles G. Yale. 1906	----
**Bulletin No. 49. Mines and Minerals of California for 1906, by Charles G. Yale. 34 pp.	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Bulletin No. 50. The Copper Resources of California, 1908, by A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorn and J. A. Edman, 366 pp., 74 illustrations. (Revised edition)	$1.50
**Bulletin No. 51. Mineral Production of California, by Counties, 1907, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 52. Mineral Production of California for Twenty-one Years, by D. H. Walker, 1907. Tabulated sheet	----
**Bulletin No. 53. Mineral Production of California for 1907, with County Maps, by D. H. Walker, 62 pp.	----
**Bulletin No. 54. Mineral Production of California, by Counties, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 55. Mineral Production of California for Twenty-two Years, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 56. Mineral Production for 1908, with County Maps and Mining Laws of California, by D. H. Walker, 78 pp.	----
**Bulletin No. 57. Gold Dredging in California, by W. B. Winston and Chas. Janin. 1910, 312 pp., 239 illustrations, 10 maps	----
**Bulletin No. 58. Mineral Production of California, by Counties, by D. H. Walker. 1909. Tabulated sheet	---
**Bulletin No. 59. Mineral Production of California for Twenty-three Years, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 60. Mineral Production for 1909, with County Maps and Mining Laws of California, by D. H. Walker. 94 pp.	----
**Bulletin No. 61. Mineral Production of California, by Counties, for 1910, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 62. Mineral Production of California for Twenty-four Years, by D. H. Walker. 1910. Tabulated sheet	----
**Bulletin No. 63. Petroleum in Southern California, by P. W. Prutzman. 1912, 430 pp., 41 illustrations, 6 maps	----
**Bulletin No. 64. Mineral Production for 1911, by E. S. Boalich. 49 pp.	----
**Bulletin No. 65. Mineral Production for 1912, by E. S. Boalich. 64 pp.	----
**Bulletin No. 66. Mining Laws of the United States and California. 1914, 89 pp.	----
**Bulletin No. 67. Minerals of California, by Arthur S. Eakle. 1914, 226 pp.	----
**Bulletin No. 68. Mineral Production for 1913, with County Maps and Mining Laws, by E. S. Boalich. 160 pp.	----
**Bulletin No. 69. Petroleum Industry of California, with Folio of Maps (18 by 22), by R. P. McLaughlin and C. A. Waring. 1914, 519 pp., 13 illustrations, 83 figs. [18 plates in accompanying folio.]	----
**Bulletin No. 70. Mineral Production for 1914, with County Maps and Mining Laws. 184 pp.	----
**Bulletin No. 71. Mineral Production for 1915, with County Maps and Mining Laws, by Walter W. Bradley, 193 pp. 4 illustrations	----
**Bulletin No. 72. The Geologic Formations of California, by James Perrin Smith. 1916, 47 pp.	----
**Reconnaissance Geologic Map (of which Bulletin 72 is explanatory), in 23 colors. Scale: 1 inch = 12 miles. Mounted	----
**Bulletin No. 73. First Annual Report of the State Oil and Gas Supervisor of California for the fiscal year 1915-16, by R. P. McLaughlin. 278 pp., 26 illustrations	----
**Bulletin No. 74. Mineral Production of California in 1916, with County Maps, by Walter W. Bradley. 179 pp., 12 illustrations	----
**Bulletin No. 75. United States and California Mining Laws. 1917, 115 pp., paper	----
Bulletin No. 76. Manganese and Chromium in California, by Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring. 1918, 248 pp., 51 illustrations, 5 maps, paper	.75
Bulletin No. 77. Catalogue of Publications of California State Mining Bureau, 1880-1917, by E. S. Boalich. 44 pp., paper	Free

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	Price Postpaid
Bulletin No. 78. Quicksilver Resources of California, with a Section on Metallurgy and Ore-Dressing, by Walter W. Bradley. 1919, 389 pp., 77 photographs and 42 plates (colored and line cuts), cloth	$2.00
Bulletin No. 79. Magnesite in California, by Walter W. Bradley. 1925, 147 pp., 62 photographs, 11 line cuts and maps, cloth	1.25
†Bulletin No. 80. Tungsten. Molybdenum and Vanadium in California. (In preparation.)	
†Bulletin No. 81. Foothill Copper Belt of California. (In preparation.)	
**Bulletin No. 82. Second Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1916-1917, by R. P. McLaughlin. 1918, 412 pp., 31 illustrations, cloth	----
**Bulletin No. 83. California Mineral Production for 1917, with County Maps, by Walter W. Bradley. 179 pp., paper	----
**Bulletin No. 84. Third Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1917-1918, by R. P. McLaughlin. 1918, 617 pp., 28 illustrations, cloth	----
**Bulletin No. 85. Platinum and Allied Metals in California, by C. A. Logan, 1919. 10 photographs, 4 plates, 120 pp., paper	----
**Bulletin No. 86. California Mineral Production for 1918, with County Maps, by Walter W. Bradley. 1919, 212 pp., paper	----
**Bulletin No. 87. Commercial Minerals of California, with notes on their uses, distribution, properties, ores, field tests, and preparation for market, by W. O. Castello. 1920, 124 pp., paper	----
**Bulletin No. 88. California Mineral Production for 1919, with County Maps, by Walter W. Bradley. 1920, 204 pp., paper	----
**Bulletin No. 89. Petroleum Resources of California, with Special Reference to Unproved Areas, by Lawrence Vander Leck. 1921, 12 figures, 6 photographs, 6 maps in pocket, 186 pp., cloth	----
**Bulletin No. 90. California Mineral Production for 1920, with County Maps, by Walter W. Bradley. 1921, 218 pp., paper	----
**Bulletin No. 91. Minerals of California, by Arthur S. Eakle. 1923, 328 pp., cloth	----
**Bulletin No. 92. Gold Placers of California, by Charles S. Haley. 1923, 167 pp., 36 photographs and 7 plates (colored and line cuts, also geological map), cloth	----
**Bulletin No. 93. California Mineral Production for 1922, by Walter W. Bradley. 1923, 188 pp., paper	----
**Bulletin No. 94. California Mineral Production for 1923, by Walter W. Bradley. 1924, 162 pp., paper	----
Bulletin No. 95. Geology and Ore Deposits of the Randsburg Quadrangle, by Carlton D. Hulin. 1925, 152 pp., 49 photographs, 13 line cuts, 1 colored geologic map, cloth	2.75
**Bulletin No. 96. California Mineral Production for 1924, by Walter W. Bradley. 1925, 173 pp., paper	.15
**Bulletin No. 97. California Mineral Production for 1925, by Walter W. Bradley. 1926, 172 pp., paper	----
Bulletin No. 98. American Mining Law, by A. H. Ricketts, 1931, 811 pp., flexible leather	3.50
Bulletin No. 99. Clay Resources and Ceramic Industry of California, by Waldemar Fenn Deitrich. 1928, 383 pp., 70 photographs, 12 line cuts including maps, cloth	2.00
**Bulletin No. 100. California Mineral Production for 1926, by Walter W. Bradley, 1927, 174 pp., paper	----
**Bulletin No. 101. California Mineral Production for 1927, by Henry H. Symons. 1928, 311 pp., paper	----
**Bulletin No. 102. California Mineral Production for 1928, by Henry H. Symons. 1929, 210 pp., paper	----

† Not yet published.

BULLETINS—Continued

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**Bulletin No. 103. California Mineral Production for 1929, by Henry H. Symons, 1930. 231 pp., paper	----
Bulletin No. 104. Bibliography of the Geology and Mineral Resources of California, to the end of 1930, by Solon Shedd	$2.50
**Bulletin No. 105. Mineral Production in California for 1930 and Directory of Producers	----
Bulletin No. 106. Manner of Locating and Holding Mineral Claims in California (with forms)	.25
**Bulletin No. 107. Mineral Production in California for 1931 and Directory of Producers	----
Bulletin No. 108. Mother Lode Gold Belt of California, by Clarence A. Logan, 1934, 240 pp., with geologic and claim maps, cloth	2.25
**Bulletin No. 109. California Mineral Production and Directory of Mineral Producers for 1932, by Henry H. Symons, 200 pp., paper	----
**Bulletin No. 110. California Mineral Production and Directory of Mineral Producers for 1933, by Henry H. Symons, 214 pp., paper	----
**Bulletin No. 111. California Mineral Production and Directory of Mineral Producers for 1934, by Henry H. Symons, 334 pp., paper	----
**Bulletin No. 112. California Mineral Production and Directory of Mineral Producers for 1935, by Henry H. Symons, 205 pp., paper	----
Bulletin No. 113. Minerals of California, by Adolf Pabst, 1938	1.75
Bulletin No. 114. California Mineral Production and Directory of Mineral Producers for 1936, by Henry H. Symons, 199 pp., paper	.80
Bulletin No. 115. Bibliography of Geology and Mineral Resources of California, 1931 to 1936, Supplementing Bulletin No. 104	1.25

PRELIMINARY REPORTS

**Preliminary Report No. 1. Notes on Damage by Water in California Oil Fields, December, 1913. By R. P. McLaughlin, 4 pp	----
**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin, 4 pp.	----
Preliminary Report No. 3. Manganese and Chromium, 1917. By E. S. Boalich. 32 pp.	.05
**Preliminary Report No. 4. Tungsten, Molybdenum and Vanadium. By E. S. Boalich and W. O. Castello, 1918. 34 pp. Paper	----
**Preliminary Report No. 5. Antimony, Graphite, Nickel, Potash, Strontium and Tin. By E. S. Boalich and W. O. Castello, 1918. 44 pp. Paper	----
Preliminary Report No. 6. A Review of Mining in California During 1919. By Fletcher Hamilton, 1920. 43 pp. Paper	.05
**Preliminary Report No. 7. The Clay Industry in California. By E. S. Boalich, W. O. Castello, E. Huguenin, C. A. Logan, and W. B. Tucker, 1920. 102 pp. 24 illustrations. Paper	----
**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----

MISCELLANEOUS PUBLICATIONS—Continued

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	Price Postpaid
**Catalogue of the Library of the California State Mining Bureau, September 1, 1892. 149 pp.	----
**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper	----
Bulletin. Reconnaisance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper	$0.25
Commercial Mineral Notes. A monthly mimeographed sheet, beginning April, 1923 (15c annually)	Free

MAPS

Register of Mines with Maps

**Register of Mines, with Map, Amador County	----
**Register of Mines, with Map, Butte County	----
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
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**Register of Mines, with Map, Plumas County	----
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**Register of Mines, with Map, San Diego County	----
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**Mineral and Relief Map of California	----
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**Geographical Map of Inyo County. Scale 1 inch equals 4 miles	----
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----

OTHER MAPS—Continued

	Price Postpaid
Geologic Map of California, 1916. Scale 1 inch equals 12 miles. Shows railroads, highways, post offices and other towns. Geological details lithographed in 23 colors. Mounted	$2.75
Unmounted	1.00
Geologic Map of California, 1938. Scale 8 miles per inch. Lithographed in 80 distinguishing colors and patterns showing geologic units. In 6 sections, each 32 in. x 42 in. Set of 6 sheets, unmounted	4.00
Sheets not sold separately.	
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92. In 4 colors (also sold singly)	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly)	40
Map of Northern California, showing rivers and creeks which produced placer gold in 1932	.25
Mother Lode Geologic and claim maps in 5 county sections: El Dorado, Amador, Calaveras, Tuolumne and Mariposa. Single sections .25c. Set of 5	1.00
Map of Mariposa County, showing principal gold mines	.25
Geologic Map of Elizabeth Lake Quadrangle, Los Angeles and Kern Counties (accompanying October Chapter of Report XXX), sold separately	.25
Map of Western Portion of Siskiyou County Showing Location of Principal Gold Mines (accompanying July Chapter of Report XXXI), sold separately	.25
Geologic Map of Redding and Weaverville Quadrangles Showing Location of Gold Mines	.25
Map of Ancient Channel System, Calaveras County	.25
Map of Ancient Channels Between San Andreas and Mokelumne Hill	.25

OIL FIELD MAPS

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 1—Sargent, Santa Clara County	$0.75
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	1.25
Map No. 3—Santa Maria, including Casmalia and Lompoc	1.25
Map No. 4—Brea Olinda and (East Portion) Coyote Hills, Los Angeles and Orange Counties	1.25
Map No. 6—Salt Lake-Beverly Hills, Los Angeles County	1.25
Map No. 7—Sunset and San Emidio, Kern County	1.25
Map No. 8—South Midway and Buena Vista Hills, Kern County	1.25
Map No. 9—North Midway and McKittrick, Kern County	1.25
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Map No. 12—Devils Den, Kern County	1.00
Map No. 13—Kern River, Kern County	1.00
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Map No. 20—Long Beach, Los Angeles County	1.75
Map No. 21-B—Portion of District No. 5, showing boundaries of oil fields—Fresno, Kings and Kern Counties	1.00
Map No. 21-C—Portion of District No. 4, showing boundaries of oil fields—Kern, Kings and Tulare Counties	1.25

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 22—Portion of District No. 3, showing boundaries of oil fields—Santa Barbara County	$0.75
Map No. 23—Portion of District No. 2, showing boundaries of oil fields—Ventura County	1.00
Map No. 24—Portion of District No. 1, showing boundaries of oil fields—Los Angeles and Orange Counties	1.00
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Map No. 27—Santa Fe Springs, Los Angeles County	1.25
Map No. 28—Torrance, Los Angeles County	1.25
Map No. 29—Dominguez, Los Angeles County	1.00
Map No. 30—Rosecrans, Los Angeles County	1.25
Map No. 31—Inglewood, Los Angeles County	1.25
Map No. 32—Seal Beach, Los Angeles and Orange Counties	1.25
Map No. 33—Rincon, Ventura County	1.50
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Map No. 37—Montebello, Los Angeles County	1.00
Map No. 38—Whittier, Los Angeles County	1.25
Map No. 39—West Coyote, Los Angeles and Orange Counties	1.25
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Map No. 43—Capitan, Santa Barbara County	1.00
Map No. 44—Mesa, Santa Barbara County	1.50
Map No. 45—Buttonwillow gas, Kern County	1.00
Map No. 46—Richfield, Orange County	1.25
Map No. 48—Mountain View and Edison, Kern County	1.25
Map No. 49—Fruitvale, Kern County	1.00
Map No. 50—Wilmington, Los Angeles County	1.25
Map No. 51—Santa Maria Valley, Santa Barbara County	1.00
Map No. 52—El Segundo and Lawndale, Los Angeles County	1.50
Map No 53—Rio Bravo, Greeley, Ten Section and Canal, Kern County	1.25

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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OF

MINES AND GEOLOGY

QUARTERLY CHAPTER

OF

STATE MINERALOGIST'S REPORT XXXIV

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

65364

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State Mineralogist

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J. C. O'BRIEN, Junior Mining Engineer (Librarian)____San Francisco

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PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919-1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field Division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

MINERAL RESOURCES OF INYO COUNTY

W. B. Tucker and R. J. Sampson, Mining Engineers

INTRODUCTION

The field work in this report was carried on at intervals from January until November 1, 1937. The writers devoted most of their attention to the mines actively in operation throughout the county, but also some to obtaining reliable information concerning the many prospects and mining claims that hold considerable promise. Much time was devoted to the nonmetallic and saline deposits of the county.

LOCATION AND DESCRIPTION

Inyo County lies along the eastern border of California and is bounded on the north by Mono County, on the south by San Bernardino County, and on the west by Fresno and Tulare Counties. The county has an area of 10,224 square miles, being the second largest county in California. Independence is the county seat, while Bishop, with about 2000 inhabitants, at present is the center of population. The other towns of importance are Lone Pine, Big Pine, Keeler and Darwin.

Within the borders of the county are both the highest point and the lowest point in the United States. Mount Whitney has an elevation of 14,501 feet, while the lowest point in Death Valley, at Salt Flat is 280 feet below sea level. The Sierra Nevada Range forms the west wall of Owens Valley, and the main divide of the Sierra Nevada forms the western boundary of the county. There are many lofty peaks in the Sierra Nevada Mountains, with elevations from 9000 feet to 14,500 feet, Mount Whitney being 14,501 feet, and next highest peak, Mount Williamson, 14,384 feet. The Inyo Range is the first range of mountains east of the Sierra Nevada. Between these two ranges lies the deep depression of Owens Valley, at whose south end is Owens Lake. The floor of Owens Valley is from two to eight miles wide. The Inyo and White mountains form the east wall of Owens Valley. The range trends northwestward, on the south being separated from the Coso Mountains by a broad depression and on the north terminating in Mount Montgomery, elevation 13,442. The average elevation of the range is 10,000 feet. The eastern border of this range is not sharply marked. In its northern part it is marked by Fish Valley, but between this valley and Saline Valley, to the south, there is an irregular mountainous area that is not clearly separated from the Inyo Range nor the mountain ranges to the east. Still farther, south, the deep elliptical depression known as Saline Valley, whose floor is 2500 feet lower than that of Owens Valley, separates the Inyo Range from the Ubehebe Range on the east. In the northeastern portion of the county, Eureka Valley is located between the White Mountains and the Last Chance Range of mountains. Panamint Valley, which is located between the Argus Range of mountains on the west and the Panamint Range of mountains on the east, extends in a northwesterly direction from the southern boundary line of the county for a distance of about 45 miles, and is from two to

10 miles in width. The Panamint Range of mountains extends from the southern boundary line of the county in a northerly direction, a distance of approximately 75 miles, where it connects with the Last Chance, and Ubehebe mountains.

The highest point of this range is Telescope Peak, with an elevation of 11,045 feet, located north of Panamint City. The Panamint Range of mountains forms the western boundary of Death Valley while the eastern limit of the valley is the Amargosa Range, which is made up of the Grapevine, Funeral and Black mountains. Death Valley extends northwesterly from the southern boundary of the county, a distance of about 90 miles to where it runs into Lost Valley. The floor of Death Valley is from five to ten miles wide.

CLIMATE

Because of the great range in the altitude of the region, the climate in different parts of it is quite diverse. In general, the climate is typical of the southern half of this Great Basin, of which it is a part. In Owens Valley the summer temperature often exceeds 100 degrees, yet owing to the low humidity, it does not become oppressive; but in the deep depressions that are encircled by high mountains, such as Saline, Panamint and Death valleys, the temperature is oppressively hot from June to October, without intermission day or night. The winters are comparatively mild in the valleys. The average precipitation ranges from 3 inches a year in Owens Valley to 40 inches on the Sierra Nevada crest. Sufficient snow falls on the higher peaks of the mountains east of the Sierra Nevada to support several small perennial streams.

DRAINAGE AND WATER SUPPLY

The principal streams of the region are the Owens River and the Amargosa River. The Owens River rises in the Sierra Nevada Mountains near San Joaquin pass, and enters Owens Valley north of Bishop, and meanders through Owens Valley southward towards Owens Lake. Practically all of its tributaries enter from the west, and are fed almost wholly by snows that accumulate just east of the main sierran divide. The water of Owens River flows into the Los Angeles aqueduct. The intake of the aqueduct is 13 miles north of Independence. This main canal has a capacity of over 800 cubic feet per second and a width of 65 feet on the bottom. It diverts the river and various tributaries as they are passed, discharging into the Hawiee reservoir 60 miles below the intake. The Hawiee reservoir has a capacity of 63,800 acre feet. The Amargosa River rises in springs north of Beatty, Nevada, and flows southward across the Amargosa Desert and through Franklin Lake to Resting Springs Lake. It enters a narrow canyon south of Tecopa, between the Black and Kingston mountains, and there spreads out forming a great dry wash, where it is joined by the South Amargosa, which rises in Silurian Lake. The river takes a broad turn to the westward around the south end of Black Mountain, and enters Death Valley flowing northwestward in the region of Saratoga Springs.

TRANSPORTATION

RAILROADS

Two railroads enter the county, the Southern Pacific and the Tonapah and Tidewater. The Nevada and California, a narrow gauge line,

a part of the Southern Pacific system, passes along the east side of Owens Valley. It connects with the Tonapah branch of the Southern Pacific Railroad at Mina, Nevada, and its southern terminus is at Keeler, on Owens Lake. The broad-gauge branch of the Southern Pacific runs from Mojave, Kern County, to Owenyo, where it connects with the narrow-gauge line from Keeler. The Tonopah & Tidewater Railroad has its terminus at Ludlow, San Bernardino County, where it connects with the Santa Fe Railroad. This railroad runs north from Ludlow, and follows the Amargosa River through the extreme eastern part of the county, serves with spur tracks the Tecopa Lead-Silver Mines, Furnace Creek borax mines, and the mining districts near the California-Nevada boundary line.

DEATH VALLEY NATIONAL MONUMENT

The Death Valley National Monument, comprising an area of approximately 1,601,800 acres, was established on February 11, 1933, and all land therein not held under valid existing rights was withdrawn from entry. The restriction thus imposed on mining in this region was removed later by passage of the Act of June 13, 1933, extending the mining laws of the United States to the Death Valley National Monument.

The Director of the National Park Service, under the direction of the Secretary of the Interior, has the supervision, management, and control of the Monument.

The Death Valley National Monument, which is located in the eastern portion of the county and extends from the San Bernardino County line north to Grapevine Canyon, includes the major portion of Death Valley. The eastern boundary along the California-Nevada boundary line is the Funeral Range of Mountains, and on the western boundary is the Panamint Range of Mountains. Within the boundaries of the Death Valley National Monument are a number of mining districts which have been active and productive in the past.

ROADS

Since the report of October, 1926, on the mineral resources of Inyo County, the roads of the county have been greatly improved and the State Highway Commission has taken over the more important routes, which routes are paved, or are being reconstructed and paved.

The main state highways are as follows:

1. The main highway route from Los Angeles, via Mojave to Bishop, enters the county south of Little Lake and runs through Owens Valley to Bishop (known as U. S. Highway 395).

2. The Midland Trail on Westgard Pass Highway, starts from Big Pine and passes through Payson Canyon, Deep Springs Valley, Oasis, to Goldfield, Nevada (State Highway 3).

3. A new highway from Olancha to Darwin Wash, across the Panamint Valley and through Townsend Pass to Stove Pipe Wells, in Death Valley, from which it crosses the Amargosa Range to Beatty, Nevada (known as State Highway 190).

4. The Big Pine and Saline Valley road leaves Big Pine and Alvord and passes through Waucoba Canyon and down Marble Canyon to Saline Valley.

5. Another route to Saline Valley from Lone Pine passes through Keeler and over Darwin-Keeler road to Lee Flats in a new highway system; from there by county road, following northward a canyon which lies east of Inyo Range of mountains to Saline Valley.

6. Another approach to Death Valley is via Baker, San Bernardino County, entering the county near Tecopa, then north to Shoshone to Death Valley Junction where it meets Highway 190. This highway is known as State Highway 127.

7. The establishment of the Death Valley National Monument has caused the National Park Service to construct new roads and improve the old roads within the monument. Such approach roads as the Trona, Ballarat and Wildrose canyon roads have been improved and widened, so as to make travel by automobile and truck quite easy. The park service has been of considerable help to mine operators within the monument in helping repair and build roads to the different mines that are under operation.

GENERAL GEOLOGY

The general geology of the county has been described in detail in the Fifteenth Report of the State Mineralogist, pp. 45 to 60, with the geological map accompanying; also shown on state geologic map of 1938.

The geology of the Inyo Range and the eastern slope of the Southern Sierra Nevada is covered in detail by Adolph Knopf in Professional Paper 110, published by the United States Geological Survey.

"The Geology of a Part of the Panamint Range" by F. M. Murphy was published in the July and October, 1932, issue of Mining in California, pp. 329-376.

Dr. L. F. Noble, geologist for the National Park Service, is at present making a geological survey of the Death Valley region included within the Death Valley National Monument, which when completed will be of great value to those interested in the geology of this region which is located in the eastern part of Inyo County.

The geology and ore deposits of the Darwin Silver-Lead Mining District are described on pp. 503-562, and the sulphur deposits on pp. 563-590.

The eastern slope of the Sierra Nevadas is a great fault escarpment. It attains its greatest and most abrupt relief west of Owens Valley, rising from 3000 feet on Owens Lake to 14,500 feet on Mount Whitney.

The escarpment of the Sierra Nevadas is composed of granite rocks. Granite forms the backbone of the Inyo and White mountains, and of the Panamint Range.

East of Owens Valley, old Paleozoic metamorphic sediments, consisting of limestone, quartzites, and schists, make up most of the mountain ranges.

These are extremely folded and faulted, due principally to granitic intrusions. Overlying the Paleozoic metamorphics of the Inyo Mountains, in places, is an unconformable series of Mesozoic metamorphic rocks consisting of crystalline limestone and slates which in places are fossiliferous. The post-Jurassic (middle Mesozoic) uplift in this region was accompanied by granitic intrusions and the great fault along the east face of the Sierra; also by mountain-making to the eastward, at

which time, or following, the Inyo, White, Panamint, and Amargosa mountain ranges were formed more or less parallel to the fault line.

Intrusions of porphyry and diorite followed, with outbursts of rhyolite, andesite and basalt.

A large area of volcanism was found in the Coso Mountains, and lava broke out along fractures on both sides of Death Valley and eastward. Molten rock also flowed from the main fault along the Sierra, eastward across Owens Valley, south of Big Pine and north of Bishop. In the meantime, early Tertiary sediments were being deposited in the Death Valley region, and saline deposits were forming from the evaporating sea waters. Smaller uplifts and earth movements took place during the readjustment of the cooling mass and Pleistocene lake deposits were laid down in several of the larger inclosed basins, such as in the lower Amargosa and Waucoba Canyons.

POWER

Electric power, generated in the Sierra west of Bishop is available in the northern and western parts of the county. The eastern and central portions of the county are dependent on internal combustion engines. Two power companies have hydro-electric plants on Bishop Creek. The Nevada-California Power Company, owning three plants, confines its operation exclusively to the State of Nevada. The Southern Sierras Power Company has two hydro-electric plants on Bishop Creek. Its lines extend from the plants on Bishop Creek down Owens Valley, with a branch to Keeler; to Big Pine and to Palmetto, Nevada.

The Bureau of Power & Light of the City of Los Angeles operates hydro-electric plants located on Cottonwood Creek, and also a plant below Haiwee reservoir.

MINERAL RESOURCES

The principal mineral resources of the county are antimony, asbestos, barytes, bentonite, borates, copper, dolomite, gems, gold, gypsum, lead, marble, molybdenum, quicksilver, slate, soda, sulphur, talc, tungsten and zinc. Deposits of feldspar, iron, niter, potash and silica occur but have not been developed. Seventeen different mineral substances were produced in 1935.

The following table shows the mineral production from the year 1880 to 1935 inclusive, and the development of the mining industry.

ACKNOWLEDGMENTS

Appreciation is here expressed for the courteous treatment and cooperation of operators and owners of properties throughout the county. Acknowledgments are especially due to Messrs. B. M. Holman, Bishop; H. A. Van Loon, Bishop; Arthur P. Cortelyou, U. S. Vanadium Co., Bishop; Roy Troeger, Estelle Mining Co., Keeler; J. P. Hart, Keeler; Ralph Merritt, Independence; Sam Spear, Lone Pine; W. A. Reid, Sierra Talc Co., Keeler; N. W. Sweetser, Ruth Mine, Trona; and F. J. Sanders, Santa Barbara.

The last complete survey of the mineral resources of Inyo County was published in Report XXII of the State Mineralogist, pp. 453 to 530, 1926, and since that publication there has been a considerable

revival of the mining of both metal and nonmetallic minerals. On January 30, 1934, the Gold Reserve Act of 1934 was passed, followed by the President's proclamation of January 31, 1934, which fixed the weight of the gold dollar at $15\frac{5}{21}$ grains, nine-tenths fine. The value of gold thereby became $35 a fine ounce.

This increase in the price of gold led to a revival of gold mining in the different gold districts of the county, such as the Argus and Panamint districts, and to the reopening of Wilshire-Bishop Creek Mine, now known as Cardinal Mine on Bishop Creek west of Bishop. With the increase in the price of tungsten, there is revival in the development of the tungsten deposits in Round Valley, and Tungsten City areas. The U. S. Vanadium Company during the past year acquired the Pine Creek Tungsten Mine, which is being rehabilitated and developed for both the tungsten and the molybdenum content. The increase in the price of lead and zinc, during the early part of 1937, led to the reopening of a number of lead-silver mines in the Cerro Gordo, Darwin, and Saline Valley districts. At Darwin, the properties of the American Metals Inc. have been acquired by the Darwin Lead Company of Los Angeles, which has installed a 50-ton concentration plant on the property to treat low-grade ores of the Defiance, Independence, and Thompson mines. The installation of two custom mills (one at Keeler Gold Mine, near Keeler, and the Journigan's mill near Emigrant Springs), has caused increased activity in gold mining in the Skidoo and other districts.

The development of the sulphur deposits in the Last Chance Range of mountains during the past three years, has resulted in the shipment of high-grade sulphur for marketing on the Pacific Coast. There has been some activity in mining and development of talc deposits in the Darwin and Saline Valley districts.

MINERAL PRODUCTION OF

Year	Gold, value	Silver, value	Lead		Copper		Zinc		Borax, value
			Pounds	Value	Pounds	Value	Pounds	Value	
1880	$48,648	$173,916							
1881	170,000	140,000							
1882	220,000	130,000							
1883	90,000	38,000							
1884	80,000	82,000							
1885	24,998	73,461							
1886	20,156	101,670							
1887	10,649	103,370							
1888	25,000	75,000							
1889	193,957	30,706							
1890	62,432	88,320							
1891	35,466	112,730							
1892	13,930	35,995							
1893	25,945	52,475							
1894	52,639	83,640	900,000	$27,000					$81,298
1895	92,142	188,329	1,498,000	46,438					40,000
1896	238,507	108,619	1,220,000	36,600					24,900
1897	159,840	50,063	564,000	19,176					
1898	137,107	73,503	580,000	21,170	49,829	$3,986			33,000
1899	114,187	57,529	662,000	28,135					24,000
1900	213,655	113,483	971,000	38,840					13,901
1901	162,406	56,573	601,000	24,040	8,566	1,349			24,250
1902	74,397	14,484	257,500	9,013	1,100	126			36,394
1903	66,045	18,200	95,000	3,420	23,450	3,098			26,400
1904	150,474	7,122	124,000	5,270	25,508	3,252			
1905	135,959	29,741	345,680	16,247	151,606	23,649			
1906	19,449	13,358	208,018	11,857	4,145	800			
1907	57,241	44,440	261,140	13,096	6,779	1,356	144,213	$8,598	*
1908	308,873	30,900	683,401	28,244	6,820	938			*
1909	457,486	47,117	2,364,137	131,199	39,888	5,073			*
1910	408,509	129,590	2,866,227	127,385	58,801	7,489			*
1911	574,945	45,678	1,182,122	53,195	27,889	3,486	*		*
1912	369,758	45,316	1,207,593	54,342	48,584	8,016	*		*
1913	237,310	136,854	3,322,308	146,182	113,860	17,648	*7,149,523	449,701	*
1914	275,000	255,000	4,626,934	180,450	336,423	44,744	399,641	20,381	*
1915	317,905	127,894	4,323,639	203,211	154,722	27,076	4,625,162	573,520	*8,162,727
1916	131,722	232,441	11,185,321	771,787	274,032	67,412	5,758,703	771,666	(1)
1917	125,394	534,599	19,318,642	1,661,403	175,273	47,850	3,535,000	359,550	(1)
1918	100,240	441,548	12,223,471	867,866	338,518	83,614	2,517,045	229,051	(1)
1919	69,560	194,151	3,643,485	193,105	169,713	31,567	1,192,353	87,042	(1)
1920	55,634	258,929	4,612,338	368,987	144,286	26,549	(1)		
1921	80,373	86,020	1,052,253	47,351	45,725	5,898			
1922	85,265	256,009	6,264,138	344,528	69,537	9,388	(1)		(1)
1923	36,702	265,023	9,541,868	667,931	77,349	11,370			(1)

* Combined to conceal individual annual output.
[1] See under 'Unapportioned.'
[2] Includes antimony, borax, gypsum, marble, molybdenum, salt, tungsten.
[3] Includes asbestos, barytes, borax, gypsum, marble, molybdenum.
[4] Includes borax, dolomite, marble, pumice, salt, soda, talc, tungsten.
[5] Includes borax, dolomite, fuller's earth, marble, volcanic ash, salt, talc, zinc.
[6] Includes borax, building stone, marble, pumice, soda.
[7] Includes borax, building stone, clay (pottery), fuller's earth, limestone, marble, pumice, soda, talc, zinc.
[8] Includes building stone, borates, fuller's earth, gems, marble, pumice, tungsten concentrates.

INYO COUNTY, 1880-1937

Soda		Soapstone and talc		Marble		Miscellaneous and unapportioned		
Tons	Value	Tons	Value	Cu. ft.	Value	Amount	Value	Substance
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1,530	$20,000	------	------	12,500	$62,500	------	------	
1,900	47,500	------	------	10,000	50,000	------	------	
3,000	65,000	------	------	3,000	24,000	------	------	
5,000	110,000	------	------	------	------	------	------	
7,000	154,000	------	------	4,000	12,000	------	------	
10,000	250,000	------	------	------	------	------	------	
1,000	50,000	------	------	------	------	20 tons	$700	Antimony.
8,000	400,000	------	------	------	------	------	------	
7,000	50,000	------	------	------	------	------	------	
*	*	------	------	20,000	20,000	300 tons	2,400	Salt.
*	*	------	------	3,000	3,000	400 tons	800	Salt.
*	*	------	------	17,000	17,000	------	------	
*	*	------	------	1,200	4,800	------	------	
*	*	------	------	1,000	4,000	------	------	
*	*	------	------	------	------	------	------	
*	*	------	------	------	------	------	1,417,217	Unapportioned, 1900-1909.
*	*	------	------	------	------	45,000 tons	31,500	Rubble.
*	*	------	------	------	------	46,450 tons ------	32,555 174	Rubble. Gems.
*	*	1,050	$5,250	------	------	------	648	Rubble.
*	*	1,000	4,400	3,200	11,500	------ 13,500 tons	835 54,000	Rubble. Salt.
*	*	390	2,060	3,500	10,500	13,500 tons	54,000	Salt.
112,937	*496,250	1,513	14,000	------	------	------	80,430	Antimony, dolomite, marble, pumice, salt.
			Totals	[1]78,400	$219,300			
				Miscellaneous stone[1], value				
10,593	264,825	685	4,606		23,040	3,596 tons ------	14,700 2,317,897	Dolomite. Other minerals.[2]
19,604	861,160	4,736	41,044		3,000	11,315 tons ------	22,630 2,639,600	Dolomite. Other minerals.[3]
(1)	------	9,635	72,549		5,000	14,390 tons 589 tons ------	32,056 854,025 2,491,727	Dolomite. Tungsten concentrates. Borax, limestone, salt, soda.
(1)	------	(1)	------		7,850	2,360 tons ------	12,000 2,097,271	Limestone. Other minerals.[4]
23,132	933,023	(1)	------		1,190	15,240 tons ------	31,080 2,214,008	Limestone. Other minerals.[5]
(1)	------	4,350	77,250		16,250	22,112 tons 1,185 tons ------	49,073 8,295 1,089,708	Dolomite. Fuller's earth. Other minerals.[6]
(1)	------	(1)	------		12,000	43,778 tons ------	72,284 1,358,207	Dolomite. Other minerals.[7]
24,116	662,747	5,981	104,976		19,500	47,542 tons ------	79,793 997,539	Dolomite. Other minerals.[8]

MINERAL PRODUCTION OF

Year	Gold, value	Silver, value	Lead		Copper		Zinc		Borax, value
			Pounds	Value	Pounds	Value	Pounds	Value	
1924	$19,997	$115,799	4,813,718	$385,098	79,995	$10,479			(1)
1925	43,774	117,763	6,307,105	548,196	73,003	10,367	145,000	$11,020	(1)
1926	26,871	77,693	6,541,741	523,339	42,462	5,945	76,889	5,767	(1)
1927	10,109	47,384	2,173,032	136,901	30,010	3,931			(1)
1928	10,781	23,948	1,733,120	100,421	22,250	3,204			(1)
1929	16,889	23,209	1,335,831	84,157	17,733	3,121			(1)
1930	20,466	42,961	3,452,159	172,608	19,607	2,549			(1)
1931	40,603	41,311	3,703,232	137,020	8,542	777			(1)
1932	42,113	24,105	2,204,108	66,123	12,672	798			(1)
1933	62,312	7,332	601,135	22,241	7,940	508	255,944	10,741	(1)
1934	266,100	25,943	530,037	19,611	33,363	2,669	721,719	31,034	(1)
1935	656,339	27,621	578,583	23,143	42,589	3,535	274,725	12,088	(1)
1936	744,135	39,895	556,399	25,594	57,230	5,265			(1)
1937	620,585	78,899	1,908,280	112,589	71,080	8,601	22,364	1,454	(1)
Totals	$8,911,328	$5,877,669	133,143,695	$8,505,429	2,770,879	$497,483	26,808,281	$2,571,613	[1]$8,466,870

[1] See under 'Unapportioned.'

[9] Includes alum, borates, building stone (tuff), fuller's earth, glauber salt, lime, limestone, magnesium, sulphate, pumice, radio galena crystals, soda (ash and bicarbonate), tungsten concentrates.

[10] Includes borates, building stone (tuff), fuller's earth, graphite, limestone, pumice, soda (ash and bicarbonate), tungsten concentrates.

[11] Includes borates, building stone (tuff), dolomite, gems, limestone, salt, tungsten concentrates.

[12] Includes borates, building stone (tuff), dolomite, fuller's earth, lime.

[13] Includes borates, dolomite, fuller's earth, gems, granite (tuff), salt, tungsten.

[14] Includes borates, dolomite, fuller's earth, gems, granite (tuff), limestone, marble, pumice, salt, tungsten.

[15] Includes barytes, bentonite, borates, dolomite, gems, granite (tuff), lime, marble, mineral water, pumice, salt, silica, talc, tungsten.

[16] Includes barytes, bentonite, borates, dolomite, lime, limestone, pumice, quicksilver, talc, miscellaneous stone.

[17] Includes bentonite, borates, dolomite, feldspar, quicksilver, silica, slate, talc, soda, sulphur.

[18] Includes bentonite, borates, pottery clay, molybdenite, silica, slate, talc, soda, sulphur, tungsten.

[19] Includes bentonite, borates, dolomite, gems, slate, soda, sulphur, talc.

[20] Includes bentonite, borates, dolomite, quicksilver, slate, talc, soda, sulphur, stone miscellaneous.

[21] Includes bentonite, borates, dolomite, onyx, quicksilver, talc, soda, stone miscellaneous, sulphur, tungsten, slate.

[22] Includes bentonite, borates, dolomite, iron ore, quicksilver, slate, soda sulphur, talc and tungsten ore.

INYO COUNTY, 1880-1937—Continued

Soda		Soapstone and talc		Miscellaneous stone, value	Miscellaneous and unapportioned		
Tons	Value	Tons	Value		Amount	Value	Substance
(1)	----------	5,942	$98,806	$12,500	17,197 tons	$37,491	Dolomite.
					----------	1,429,925	Other minerals.[9]
(1)	----------	5,335	89,134	----------	----------	1,764,891	Other minerals.[10]
					2,275 tons	20,130	Fuller's earth
60,473	$1,232,081	6,487	98,563	12,000	300 tons	1,750	Pumice.
					----------	831,695	Other minerals.[11]
53,328	1,293,379	7,009	99,416	6,000	344 tons	2,496	Pumice.
					----------	920,218	Other minerals.[12]
86,664	1,292,165	8,563	121,177	44,831	163 tons	1,630	Pumice and volcanic ash.
					----------	234,410	Other minerals.[13]
70,440	1,525,060	8,274	120,875	224,625	----------	298,275	Other minerals.[14]
67,119	1,273,098	(1)	----------	310,675	----------	438,409	Other minerals.[15]
56,251	903,511	(1)	----------	(1)	----------	224,486	Other minerals.[16]
(1)	----------	(1)	----------	5,800	431 tons	4,845	Pumice and volcanic ash.
					----------	580,237	Other minerals.[17]
					48,487 tons	164,987	Dolomite.
(1)	----------	(1)	----------	18,690	894 tons	4,150	Pumice and volcanic ash.
					----------	724,346	Other minerals.[18]
(1)	----------	(1)	----------	66,081	673 tons	5,115	Pumice and volcanic ash.
					----------	877,163	Other minerals.[19]
(1)	----------	(1)	----------	(1)	594 tons	10,034	Pumice and volcanic ash.
					----------	827,046	Other minerals.[20]
(1)	----------	(1)	----------	(1)	1,567 tons	18,492	Pumice and volcanic ash.
					----------	633,466	Other minerals.[21]
(1)	----------	(1)	----------	22,087	2,721 tons	29,518	Pumice and volcanic ash.
					----------	565,276	Other minerals.[22]
[1]629,107	$11,883,779	[1]70,950	$954,106	$794,789	----------	$27,739,936	

METALS

ANTIMONY

Nemo Canyon Antimony Mine. It comprises 6 claims located in Nemo Canyon, in the Panamint Range of mountains, six miles northeast of Wildrose; elevation, 5000 to 6000 feet; owner, Farlansee Wells, of Death Valley Junction. Development consists of open cuts and shallow shafts. Samples taken from the deposit were reported to carry 40% antimony.

Wildrose Mine. This deposit is located in the Wildrose Mining District, on the western flank of the Panamint Mountains, south of Wildrose Canyon and 45 miles by road north of Trona; elevation, 5000 ft. Holdings comprise 4 patented claims; formerly owned and worked by the Western Metals Corp., of Los Angeles. This company mined approximately 4000 tons of ore reported to carry 42% metallic antimony. Eleven claims were recently located by T. F. Pierson and Associates, of Los Angeles.

Bibl.: State Mineralogist's Report XII, p. 21; XV, p. 60; XXII, p. 462.

Williams and Johnson Antimony Mine. It is located on the eastern slope of the Argus Mountains, between Revenue and Shepherd canyons, 14 miles by road north of Trona; owners, Ralph Williams and George Johnson, Bishop, Calif. Idle.

COBALT

Bishop Silver-Cobalt Mines. It comprises 6 claims situated in the Sierra Nevada Range of Mountains, at an elevation of 11,000 to 12,000 ft., on a ridge east of Long Lake, in Sec. 14, T. 9 S., R. 31 E., M. D. M., 25 miles southwest of Bishop. The property is reached by auto road to Parcher's Camp from Bishop, a distance of 23 miles; then by trail from South Lake to Long Lake, a distance of 2½ miles; owner, Bishop Silver-Cobalt Mines, Inc., Jack O'Brien, president, Bishop, Calif. The discovery of cobalt on the property was made by Jack O'Brien in 1920.

On the Copconis claim cobalt occurs as coatings and incrustations of erythrite (cobalt bloom) associated with argentite, arsenopyrite, chalcopyrite and pyrite in quartz-barite vein on contact of limestone. There are also coatings of annabergite which is an indication of the presence of nickel minerals that have been oxidized and it is often associated with erythrite. The ore carries values in gold, silver, copper and cobalt, with traces of nickel. The gangue minerals are quartz, calcite, barite, feldspar and wollastonite. The lode outcrops for a distance of 3000 ft. in a northerly and southerly direction. The width of mineralized vein outcrop is about 500 ft. Dip of lode is 70 to 80° W. This lode of crystalline rocks occurs in granite and in a number of places there are sills of granite intruded. On ridge southeast of main workings, there is a massive belt of dolomite which strikes N. 20° E. This dolomite, near contacts with crystalline rocks, is mineralized with argentite, arsenopyrite, galena, pyrite with values

in gold. The mineralization extends into the dolomite for widths of 30 to 100 ft. Samples at different points along this dolomitic limestone are reported to carry from 0.21 to 0.50 oz. in gold and from 14 oz. to 31.00 oz. in silver per ton.

The principal development work has been confined to the Copconis claim. At an elevation of 11,500 ft., a crosscut tunnel was driven N. 20° E. 146 ft. to cut the orebody developed by opencuts along the outcrop. These opencuts are 85 ft. in elevation above tunnel level. The orebody developed by opencuts along the outcrop is 30 ft. in width and 300 ft. in length. The face of the tunnel is reported in ore. Samples of ore taken from two opencuts above the tunnel are reported to have an assay value of .03 oz. in gold, 25.07 oz. in silver, with 2.49% in cobalt. In opencut south of tunnel, there is a vein of quartz 2 ft. wide with incrustations of cobalt bloom. Over a width of 8 ft. to contact with limestone on footwall, the quartz-rock is heavily stained with cobalt bloom. A shipment of ore to the United States Smelting Co., assayed 70.40 oz. in silver and $4.96 per ton in gold.

A drift has been started south from the present tunnel level to intersect cobalt-silver orebody exposed on the surface and the possibilities appear favorable to the development of an orebody carrying values in cobalt and silver.

One man is employed on development.

COPPER

There are deposits of copper in many localities in Inyo County but at the present time there is practically no activity in their development. The greatest production of copper has come from its association with gold, silver and lead ores containing a small percentage of copper.

Copper ores occur in the Ubehebe, Darwin and Greenwater districts. In the Ubehebe and Darwin districts, the ores are found mostly in limestone, in contact with quartz-monzonite or close to it. The Greenwater District is on the eastern slope of the Black Mountains. In the above-mentioned districts the ore consists of oxide of copper, principally malachite, azurite, chrysocolla and cuprite.

For information on different mines the reader is referred to Bulletin 50, State Mineralogist's Report XV, pp. 71, 73; XXII, pp. 463 to 465.

GOLD

There has been considerable activity in gold mining throughout the county from 1934 to date due to increase in the price of gold to $35 per fine ounce.

A number of formerly productive gold properties have reopened and are under development in the Argus, Panamint, Inyo, White, and Funeral mountains. The most noteworthy has been the reopening of the Wilshire-Bishop Creek Mine by the Cardinal Gold Mining Company, and at present writing it is the largest gold producer in the county. In the Wildrose Mining District in the Panamint Range the Skidoo Mine has been reopened during the past two years, the ore from this property being hauled to Journigan's mill, located near Emigrant Springs, for treatment.

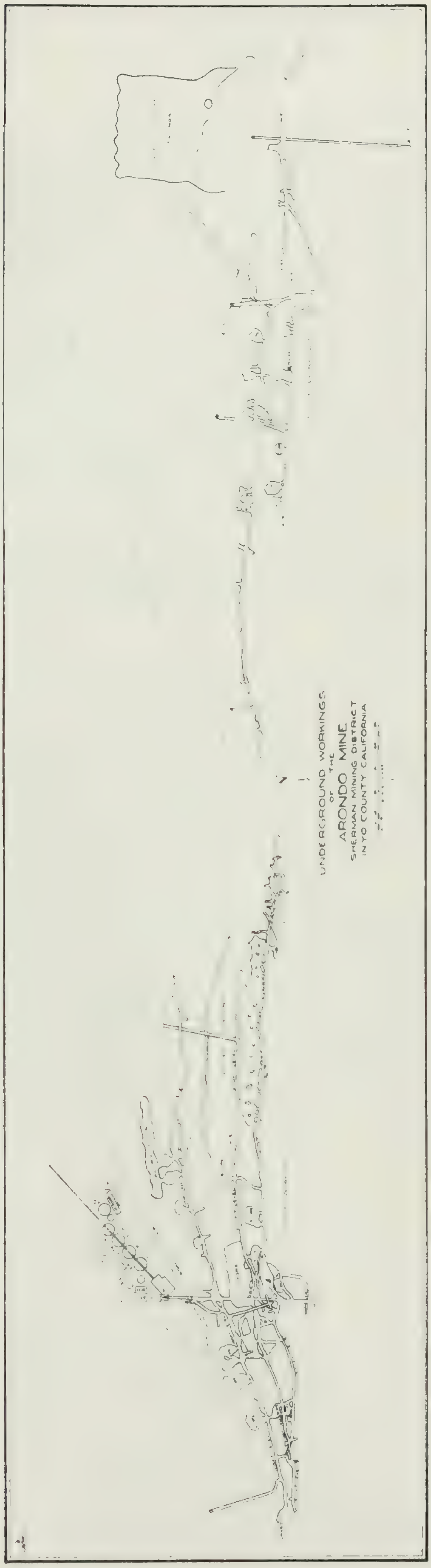

UNDERGROUND WORKINGS
OF THE
ARONDO MINE
SHERMAN MINING DISTRICT
INYO COUNTY CALIFORNIA

FIG. 1.

In this district an important discovery was made on the Del Norte group of claims a few miles north of the Skidoo Mines, indicating a large deposit of low-grade gold ore. In the Argus Range the Arando, Ruth and Mohawk mines have been under operation with some production. The gold placers of Mazourka and Marble canyons in the Inyo Range are being worked in a small way, and some production made. The Cottonwood and Crooked creek placers in the White Mountains on the boundary line of Inyo and Mono counties are being prospected and tested for the purpose of being operated with mechanical equipment.

Alabama-Mohawk Mine (Mohawk). This property comprises 5 claims, situated in the Alabama Hills, 5 miles northwest of Lone Pine; owner, James H. Hodgman and Frank Hilton, of Lone Pine, California; under lease and bond to Alabama Blue Ridge Mining Company, V. R. Ingalls, president, 120 N. Small Drive, Beverly Hills, California.

The vein occurs along an andesitic dike in granite. The vein varies from 2 in. to 18 in. in width. Strike N. 50° W., dip 65° SW. The vein quartz is mineralized with free gold, hematite, chrysocolla, pyrite and chalcopyrite. Development consists of a tunnel driven N. 55° W., 326 ft. At 130 ft. from portal, connects with shaft at a depth of 54 ft. below collar, and shaft extends to depth of 56 ft. below tunnel level. At 222 ft. from portal, a winze was sunk to a depth of 26 ft. connecting with stope from lower tunnel workings.

Equipment consists 118 cu. ft. Denver-Gardner compressor driven by Spillman gas engine. At the shaft there is a 12 h.p. gas engine hoist. Mill equipment consists of 10-ton ball mill, with amalgamation plates and one Wilfley concentrator.

Five men employed.

Anthony Mine (Gold Bug). It comprises 5 unpatented mining claims, situated in the Panamint Range of mountains, on the south side of Pleasant Canyon, 2 miles east of Ballarat; elevation 4200 ft.; owner, Mrs. Ada Norris, Trona, California. The property is described under the name of the Gold Bug Mine in "Mineral Resources of part of the Panamint Range," Report XXVIII of the State Mineralogist, pp. 368, 369.

Arando Mine. This property comprises 26 unpatented claims situated in T. 23 S., R. 43 E., in the Sherman Mining District, on the eastern slope of the Argus Range of mountains, 12 miles north of Trona; elevation, 4000 ft.; owners, Alice H. McIntosh, of Trona, California, and Judge Russ Avery, 214 N. Rossmore, Los Angeles. The property is under lease and bond to the Arando Mines, Inc., 1023 Wall St., Los Angeles; Maurice Shinbane, president; William Rosevelt, secretary. The company operated the mine from March 4, 1934, to November 1, 1936, when operations were suspended. In March, 1938, the property was leased to Henry P. Smith, South Pasadena, California.

The vein is a porphyry intrusion which occurs along a fault fissure in granite. The outcrop is traceable for a distance of some 6000 ft. The strike is east and west with a dip of 54° S. It has a width of 6 to 40 ft. The vein-filling is porphyry, containing considerable quartz with heavy talcose gouge on both foot and hanging wall. The ore is oxidized gold quartz heavily iron-stained, the vein matrix showing considerable hematite. The gold occurs in a very fine state.

G. L. Dean acquired the property in 1901 from the original locators. Ore mined by Dean was hauled to the Slate Range Mill, operated by Dean & Jones. An incline shaft was sunk to a depth of 100 ft. on what is called the east orebody. On the 100-ft. level Dean developed an orebody 900 ft. in length and 40 ft. in width.

Reported to have an average value of $4.25 per ton in gold. Smiley R. Jones became interested in the property with Dean, and the mine was actively worked until 1906. The main or east shaft was sunk on incline of 55 degrees to a depth of 435 ft., with levels at 24, 34, 110, 175, 225 and 310 ft. The total amount of underground workings from this shaft was about 7000 ft.

It is reported that 24,000 tons of ore mined and milled had an average of $8.25 per ton in gold.

J. K. Miller, of Los Angeles, acquired the property in 1907, and operated the mine until 1916. In 1920 the property was leased to the North Star Mining Company, the principals being the Rogers Bros., of Los Angeles.

This company sunk the Cuba No. 1 shaft (Cuba tunnel shaft) on an incline to a depth of 235 ft. with levels at 150 and 200 ft. below the Cuba tunnel.

In 1934 the property was leased to Arando Mines, Inc., of Los Angeles, which company operated the property until January, 1937. During this period the Cuba No. 2 shaft was sunk on incline of 54° to a depth of 400 ft.; with levels at 100, 200, 300 and 400. The 100-ft. level is Cuba tunnel, with drift 500 ft. east and 100 ft. west of shaft. On this level, about 100 ft. west of the portal of the tunnel, an ore shoot was developed, which had a length of 100 ft. with a width of 6 to 20 ft., and reported average value of $6 per ton in gold. On the 300-ft. level drift west 300 ft. and 800 ft. east. At 225 ft. east of shaft cut oreshoot which is 500 ft. in length, with an average width of 20 ft. Value reported to be from $4 to $6 per ton in gold. (See map, Fig. 1.)

On the 400-ft. level crosscut north 90 ft. Estimated tonnage is 10,000 tons of ore between the 400 and 300 ft. levels with an average value of $6.40 per ton, and 10,000 tons above 300 ft. level with an average value of $6 per ton.

Mine equipment: 25 hp. Western Enterprise single drum hoist, 100 cu. ft. Laidlaw compressor, one-ton ore skip.

Mill: 50-ton coarse-ore bin to Gates gyratory crusher driven by a 25 hp. Fairbanks-Morse gas engine; from crusher conveyed to 14 in. by 22 in. Joshua Hendy rolls, where ground to $\frac{1}{8}$ in. size. Product from rolls conveyed by 18 in. belt conveyor to four 5 ft. by 25 ft. steel cyanide tanks,. total capacity per 24 hours being 70 tons; one 4 ft. by 25 ft. solution tank; one sump tank, 5 ft. by 25 ft.; two 10-compartment zinc boxes. Tailings from the tanks are conveyed by a 16 in. belt conveyor 300 ft. in length to dump. Water supply is secured from springs 3 miles west of the mine through 3 miles of $2\frac{1}{2}$ in. pipe line, flowing by gravity to a storage tank with a capacity of 17,000 gallons situated north of Homeward Canyon; from the storage tank pumped by a Worthington Triplex pump over hill a distance of one-half mile through a $2\frac{1}{2}$ in. pipe line to a storage tank above the mill, which has a capacity of 17,000 gallons. Ten men are employed.

Ashford Mine (formerly Golden Treasure), comprising 26 claims, is on the western slope of the Funeral Mountains, 30 miles by road west of Shoshone on the east side of Death Valley; elevation, 2000 ft.; owners, Henry J. and Louis R. Ashford.

Four quartz veins occur in the gneiss. They have been faulted and possibly rotated. The owners believe the general strike to be about N. 80° E., whereas the faulted segments which have been worked strike approximately N. 15° E.; dip about 65° E. The widths vary from 6 in. to 4 ft. Mineralization consists of quartz, chalcopyrite, some chalcocite and bornite, with free gold. Oxidation apparently has taken place to a depth of about 120 ft. In one of the veins the principal values are in silver, probably contained in tetrahedrite and galena.

Development consists of a 320 ft. shaft sunk on an average inclination of about 60°. On the 76-ft. level, crosscut northwest 70 ft. to vein, drift south 60 ft., north 20 ft.; 96-ft. level, drift north 90 ft.; 180-ft. level, drift south 65 ft. On the 180-ft. level, at the shaft, there is a stope 60 ft. long, 55 ft. high. Width of ore is said to average about 15 in. North of the shaft in a canyon, a crosscut tunnel has been driven north 100 ft. to the vein; drift south 120 ft. Here the vein has been stoped for a length of about 170 ft.; average width about 2 ft., maximum 4 ft. Some 400 ft. southwest of the shaft and 150 ft. below the collar, a crosscut tunnel has been driven east 215 ft. to a vein and a winze sunk to a depth of 35 ft. Mineralization here shows, principally, galena and tetrahedrite, carrying silver. At 200 ft. from the portal, a drift has been driven north 375 ft. to connect with the shaft on the 180-ft. level.

Total shipments have amounted to about $135,000; $18,000 of which has been shipped in the last two years. Shipments have averaged about $70 per ton. Equipment consists of Ingersoll-Rand portable compressor and camp. Three men are working.

Bibl.: (Golden Treasure) State Mineralogist's Reports XV, pp. 78-79; XXII, p. 469.

Big Horn Mine. It comprises 8 claims and one millsite, situated in the Beveridge Mining District, between Hunter and Beveridge canyons, on the east slope of the Inyo Range, 10 mi. NE. of Lone Pine; elevation, 6000 ft.; owners, Sam R. Spear and M. A. Wilson, of Lone Pine, California. The mine was discovered in 1877 by W. L. Hunter, who built three arrastras in Hunter Canyon to treat the ore in 1878, and the property was operated by Hunter until 1893. He is reported to have recovered between $8,000 and $10,000 during the period of his ownership of the property. Three parallel veins occur in granite, strike N. 80° E., dip 30° N., widths vary from 2 to 8 feet. The principal development is on the Bronco-Hunter vein; the ore occurs in irregular lenses in a white quartz vein which varies in width from 4 to 8 feet.

The quartz is mineralized with galena, red oxide of copper, chalcopyrite, pyrite, free gold; also gold occurs in galena. Twenty-five tons of silver ore shipped from the property assayed gold, 4.68 oz.; silver, 16.60 oz.; copper, 2%; lead, 2%; value of $155.34 per ton. Development consists of incline shaft sunk on the vein to a depth of 380 ft. with levels at 100, 200 and 300 feet. About 300 ft. west of this shaft and 150 ft. in elevation above is tunnel No. 1, driven on the vein for a distance

of 200 feet. About 75 ft. in elevation above No. 1 tunnel and 150 ft. west of portal is tunnel No. 2, which has been driven west on the vein 650 feet. Incline shaft 100 ft. in depth connects with these workings. Ore is sorted and packed on mules by trail from the mine to Long John Canyon, a distance of 8 miles, then hauled by truck, a distance of 8 miles to Owenyo for shipment to smelters at Salt Lake City. Ore has to

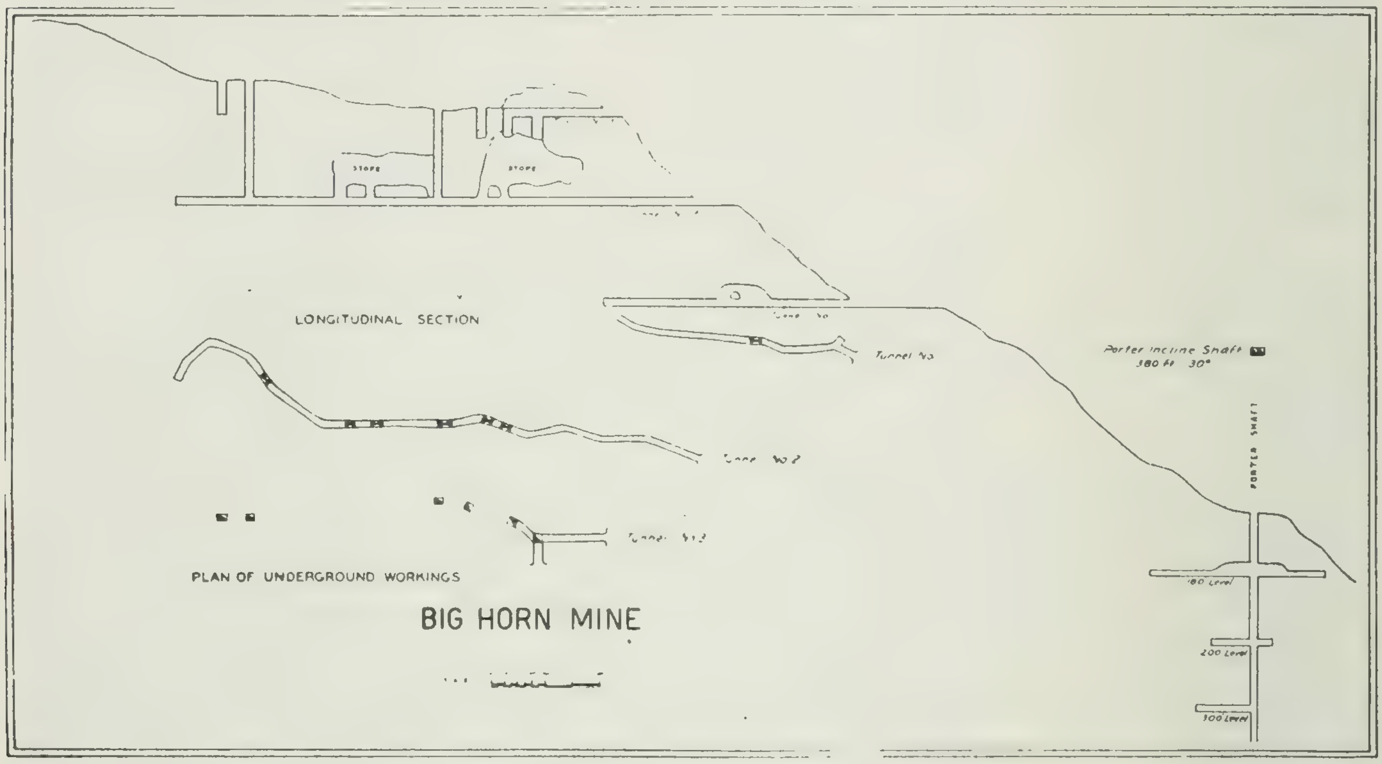


FIG. 2.

carry better than $50 per ton. The property has been worked off and on since 1900 by owners with a small crew. Last production of high-grade ore was made in September, 1934. Idle. (See map, Fig. 2.)

Big Tee Mine. It comprises 4 claims situated in the Coso Mining district, in Coso Range of mountains, 3 miles south of Cold Springs and 16 miles southwest of Darwin; elevation, 5300 ft.; owner, E. J. Reeves, Darwin, California. Three parallel quartz veins occur in granite. Widths vary from 9 in. to 2 ft. Development consists of a shaft 20 ft. deep and a trench 50 ft. in length by 5 ft. deep. Three tons of ore mined from the trench is reported to have assayed $45 per ton in gold. Idle.

Black Eagle Mine. It is situated on the west flank of the Inyo Mountains, 4 miles east of Kearsarge, a station on Owens Valley Branch of the Southern Pacific Railroad; elevation, 8000 ft. Holdings comprise 3 claims known as Black Eagle, Bellview and Black Eagle millsite. Owner, A. T. Smith, of San Clemente, California, and George A. Lewis, 3579 Fourth Ave., San Diego, California; under lease to First National Mines Company, c/o Homer Johnstone, 801 Bartlett Bldg., Los Angeles, California.

There are three parallel veins on the property, one of which has been developed. The Black Eagle vein occurs on the contact of granite and limestone. The vein trends N. 70° E., and dips nearly vertical, with a slight inclination to the south. The vein varies in width from 18 in. to 3 ft. Mill equipment consists of a Hardinge ball mill, Dorr classifier, Merrill amalgamator and flotation cells. The mill is located

at Willow Springs, 2800 ft. below the mine. Idle, but they expect to resume operations in the early spring.

Bibl.: State Mineralogist's Reports XV, p. 75; XVII, p. 279; XXII, p. 466; U. S. G. S. Bulletin 540, p. 116; U. S. G. S. Prof. Paper 110, pp. 120-121.

Blue Belle Mine. It comprises 2 claims situated on the east slope of the Argus Range of mountains, in the Modoc Mining District, 34 miles north of Trona; elevation, 5000 ft.; owner, Jack Cress Estate and Marie E. Streger, of Los Angeles; under option to Chas. F. Hamilton, of Los Angeles. The vein of quartz occurs along contact of granite and limestone; strike N. 50° W., dip 47° SW., width 4 to 6 ft. Development consists of a crosscut tunnel driven 90 ft. north to contact, with drift 150 ft. northwest on the vein. A small amount of stoping has been done above this level. At about 200 ft. northwest of these workings is another tunnel 100 ft. in length. The lower tunnel on the Blue Belle vein is about 300 ft. in elevation below these workings. This tunnel is driven northwest 200 ft. on a narrow quartz vein. Near the face of this tunnel is a raise 50 ft. in height which connects with another tunnel. There are five tunnels varying in length from 50 to 300 ft. A tram line runs from the lower tunnel to the mill, a distance of 500 ft.

Blue Eagle Mine. It comprises three claims in the Coso Mining District about 6 miles southwest of Coso. C. W. Woodson, C. O. Woodson and Roscoe Williams, of Los Angeles, are the owners. Development consists of a tunnel driven N. 14° W. 100 ft., with a crosscut east for 110 ft. and west for 15 ft. [illegible] tons of ore mined and shipped are said to have averaged $48 in gold per ton.

Blue Rock Mine. It comprises 4 claims situated in the Coso Mining District, two miles south of Cold Springs, and 12 miles west of Darwin; owners, J. H. Crouch and Walter Palmer, of Darwin. A vein of quartz 4 ft. in width, occurs in rhyolite; strike, N. 55° W., dip 40° NE. Development consists of a shaft 40 ft. in depth.

Two men are employed.

Bonanza Mine, comprising 2 claims, is in the Coso Mountains, 6 miles south of Cold Spring and approximately 7½ miles south of Coso; elevation about 4700 ft.; owner, Western Consolidated Gold Mines, Ltd., Darwin, Calif.; under lease to R. L. Tuttle, 845 South Plymouth, Los Angeles.

A quartz vein in the granitic country rock strikes N.-S., dips 33° W. It varies in width from a mere seam to a maximum of 5 ft. The vein-filling is brecciated quartz, cemented with iron oxide. The gold is all free. The ore occurs in short, lenticular shoots.

Development consists of a crosscut east about 575 ft. to the vein; drift south 200 ft. At 100 ft. from crosscut, there is a raise 200 ft. on the dip. At 245 ft. from the portal, there is a raise 50 ft. and at 200 ft. from the portal, another raise about 80 ft. At 90 ft. above these workings is another tunnel 185 ft. long and 100 ft. south is another 100-ft. tunnel.

A small cyanide leaching plant composed of four 8-ft. tanks is being erected at the mine. Water is to be hauled from Cold Spring.

Four men are working.

Brown Monster-Reward Mines (Eclipse). This property comprises two patented claims known as Reward and Brown Monster, 6 claims held by location and two millsites, situated in the Russ Mining District, on the west slope of the Inyo Range of mountains, 10 miles north of Lone Pine, and two miles east of Manzanar, a siding on the Owens Valley Branch of the Southern Pacific Railroad; elevation, 4000 to 5000 ft.; owners, Guy Eddie and Chas. De Corse, 643 Rives-Strong Bldg., Los Angeles. The vein was discovered in 1878 and worked from 1880 to 1914 by the *Reward Consolidated Mining Company.* The property

PHOTO. 1. Reward Mine on west slope Inyo Range of Mountains, Manzanar, Inyo County.

was idle until 1935, when owners operated the Brown Monster Mine from April, 1935, to February, 1936, during which time they shipped about 2000 tons of ore reported to have an average value of $25 per ton in gold. In March, 1936, the property was acquired under lease by the *Monte Carlo Mines, Inc.;* A. J. Israel, president; W. H. Cook, general manager, and operated until August, 1936. During this period the ore mined from Reward Mine was hauled to the Mt. Whitney-Union Mill for treatment, but due to poor recovery made by flotation, operations were suspended. In Jan. 1936, it was leased to T. L. Brite, of Lone Pine. Ore mined from Reward vein was reported to have an average value of $11 per ton in gold and silver. The Brown Monster and

Reward veins conform to the bedding of enclosing limestone. The Brown Monster vein strikes N. 70° W., dip 25° NE., width varies from 4 to 12 ft. Reward vein strikes N. 40° W., dip 40° NE., width 6 ft. The vein material is mineralized with gold, associated with pyrite, galena, chalcopyrite, azurite and malachite. Ore shoots developed on Brown Monster vein vary from 100 to 200 ft., with an average width of 4 ft.; ore-shoot on Reward vein, 150 to 300 ft. in length, average width being 6 ft.

Development-Reward Workings. No. 1 tunnel is driven 1200 ft. N. 55° E., 650 ft. to the vein and then drift southeast 800 ft. About 50 ft. above this tunnel level is No. 2 tunnel level which is driven southeast 800 ft.; No. 3 tunnel level is 700 ft. in length; No. 4 tunnel level is 600 ft. in length; No. 5 tunnel level is 400 ft. in length; No. 6 tunnel

PHOTO. 2. Open stope on Brown Monster Vein, Brown Monster Mine, Manzanar, Inyo County.

level is 300 ft. in length. The intervals between No. 2 tunnel levels and the others above are 25 ft. Ore-shoots stoped from No. 2 tunnel level to the surface.

Brown Monster Workings. The Brown Monster incline shaft is sunk along a fault, which strikes N. 40° E., to depth 300 ft. with levels at 60, 96, 200 and 250 ft. On the 96-ft. level gold values were discovered in limestone southeast of incline shaft, and in the footwall of the Reward vein on No. 2 tunnel level.

The gold was associated with oxides, carbonates and sulphides of lead, copper and iron, with considerable graphitic slate. The ore was stoped from the 200-ft. level to surface east and west of incline shaft for a length of 200 ft. with average width of 6 ft. On the ridge north of the Brown Monster incline shaft, and about 500 ft. in elevation above collar of the shaft, the vein is exposed on the surface for distance of

500 ft. Ore-shoot developed along the surface outcrop is about 200 ft. in length, with average width of 8 ft. Three incline shafts were sunk on the vein to depths of 30 ft. and 90 ft.; these shafts are about 75 ft. apart. Fifteen hundred tons of ore mined and shipped from these workings are reported to have had an average value of $25 per ton in gold and silver, with 1.5% to 2% lead content.

Equipment: C. P. 300-cu.-ft. compressor, 1500-ft. aerial tram, capacity of the buckets 700 lb. A Williams gasoline hoist drives the tram. Reward incline tram is 1500 ft. in length; 40-ton ore bin.

Ten men are employed in selective mining on the Brown Monster vein, the ore being shipped to Burton Brothers' mill at Tropico, Kern County, for treatment. Ore treated is reported to carry $25 to $40 per ton in gold.

Bibl.: State Mineralogist's Reports VIII, p. 263; XII, p. 136; XIII, p. 180; XV, p. 83; XXII, p. 473; Report of the Director U. S. Mint, 1883, p. 160; U. S. G. S. Bull. 540, pp. 116, 118; U. S. G. S. Prof. Paper 110, pp. 121, 122.

Burgess Mine (Iron Sides). It comprises 19 claims, situated in the Beveridge Mining District, on the summit of the Inyo Range of mountains, 10 miles east of Mt. Whitney, a station on the California & Nevada Railroad; elevation, 9200 ft.; owners, Mrs. Kate Wells, Big Pine, Calif.; under lease to A. B. Gould, Lone Pine, Calif.

A series of parallel quartz veins occur in limestone of the Triassic age with one vein occurring along contact between limestone and diorite porphyry. Dikes of diorite porphyry occur in the vicinity of the mine. Width of veins varies from 12 in. to 2 ft. Strike of the vein is N. 30° W., dip 60° SW.; developed by an incline shaft 200 ft. in depth. West of this shaft are two vertical shafts sunk to a depth of 60 ft. On the east slope of the ridge there is a crosscut tunnel 700 ft. in length. The ore is a milky-white quartz, carrying gold associated with galena. Equipment consists of gasoline hoist and compressor.

Two men are employed.

Bibl.: State Mineralogist's Report XVII, p. 280; U. S. G. S. Bull. 540, p. 119; U. S. G. S. Prof. Paper 110, pp. 122-123.

Burro, New Discovery and Gem Mines. This property comprises 5 claims, situated in Jail Canyon, 14 miles north of Ballarat in the Panamint Range of mountains; elevation, 3700 ft.; owner, R. D. Warneck, Trona, California.

Idle.

Bibl.: State Mineralogist's Reports XV, pp. 81-82; XVII, pp. 470-471; XXVIII, 364-366.

Buster Brown Mine. It comprises 3 claims, adjoining World Beater Mine, situated in Pleasant Canyon on the west slope of Panamint Range of mountains, about 6 miles east of Ballarat; elevation, 5000 ft.; owners, L. E. Kain, of San Pedro; Gustaffison, Leavitt, and Hyatt, Long Beach, California.

The vein occurs on contact of diorite and schist, has a NE.-SW strike and dips SE. Widths vary from 2 to 12 ft. Developed by tun-

nels. Ore mined is reported to carry $30 per ton in gold. Equipment consists of 5-stamp mill and cyanide plant. Four men are employed.

Cardinal Gold Mining Company took over the Wilshire-Bishop Creek Mine from the Anglo-American Mining Corporation, Ltd., in the latter part of 1933. The property consisting of 34 claims, 12 of which are patented, is on the east slope of the Sierra Nevada, on the middle fork of Bishop Creek, 17 miles SW. of Bishop; elevation, 8500 ft. Officers of the company are: A. J. Inderrieden, president; R. H. Travers, vice president; G. H. Janeway, secretary-treasurer, 410 Roosevelt Bldg., Los Angeles, California; mine address, Victor Bongard, general manager, Bishop, California.

The orebodies occur along a zone of fracturing in the central portion of a body of quartzite. The quartzite, which is partially enclosed by intrusive granite and monzonite, is about 800 ft. wide. Its strike is N. 50° W., dip 60° SW. The lines of fracture, along which the mineralization occurs, strike N. 55° W., and dip 70° NE. Both walls are

PHOTO. 3. Cardinal Gold Mine, Bishop Creek, Inyo County.

determined by assay. The average width mined is about 8 ft., although, locally it may be much wider. Mineralization consists of fine free gold, auriferous pyrite, pyrrhotite, arsenopyrite, chalcopyrite and some sphalerite. Four principal ore shoots have been developed. They vary from 20 to 300 ft. in length and from 6 to 16 ft. in width. The ore bodies to the northwest of the shaft have been displaced 130 ft. to the southwest by the Haggerty Fault, strike N. 60° E., dip 45° SE. Narrow granitic sills also cut the orebodies. These sills are displaced by the Haggerty Fault.

The ore carries $10 to $12 per ton, approximately 99% of which is gold, with a little copper and silver. The ratio of concentration in the mill is about 30 to 1, with a recovery of 92%. Production to date (November, 1937) by this company is $1,570,000.

Development consists of 600-ft. shaft, the first 100 ft. of which is vertical, the remaining 500 ft. is inclined 68° to the NW. Levels have been driven at 60, 200, 300, 400, 500, and 600 ft. horizons. Approximately 4000 ft. of development work has been done. The

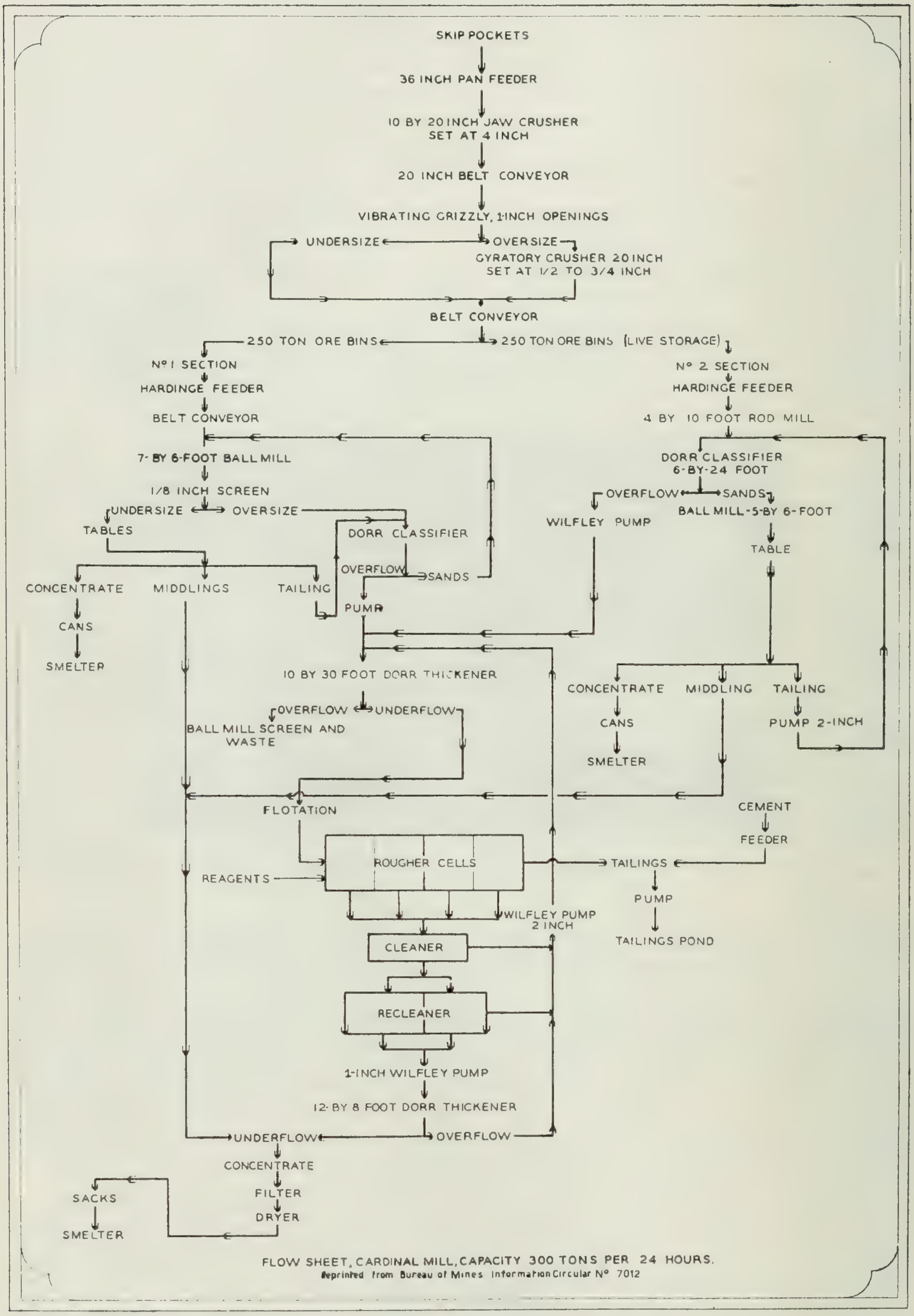

SKIP POCKETS
36 INCH PAN FEEDER
10 BY 20 INCH JAW CRUSHER SET AT 4 INCH
20 INCH BELT CONVEYOR
VIBRATING GRIZZLY, 1-INCH OPENINGS
UNDERSIZE
OVERSIZE
GYRATORY CRUSHER 20 INCH SET AT 1/2 TO 3/4 INCH
BELT CONVEYOR
250 TON ORE BINS
250 TON ORE BINS (LIVE STORAGE)
Nº 1 SECTION
HARDINGE FEEDER
BELT CONVEYOR
7- BY 6-FOOT BALL MILL
1/8 INCH SCREEN
UNDERSIZE
OVERSIZE
TABLES
DORR CLASSIFIER
OVERFLOW
SANDS
CONCENTRATE
MIDDLINGS
TAILING
CANS
SMELTER
PUMP
Nº 2 SECTION
HARDINGE FEEDER
4 BY 10 FOOT ROD MILL
DORR CLASSIFIER 6-BY-24 FOOT
OVERFLOW
SANDS
WILFLEY PUMP
BALL MILL-5-BY 6-FOOT
TABLE
CONCENTRATE
MIDDLING
TAILING
CANS
SMELTER
PUMP 2-INCH
10 BY 30 FOOT DORR THICKENER
OVERFLOW
UNDERFLOW
BALL MILL SCREEN AND WASTE
FLOTATION
CEMENT
FEEDER
REAGENTS
ROUGHER CELLS
TAILINGS
PUMP
TAILINGS POND
WILFLEY PUMP 2 INCH
CLEANER
RECLEANER
1-INCH WILFLEY PUMP
12- BY 8 FOOT DORR THICKENER
UNDERFLOW
OVERFLOW
CONCENTRATE
FILTER
DRYER
SACKS
SMELTER
FLOW SHEET, CARDINAL MILL, CAPACITY 300 TONS PER 24 HOURS.
Reprinted from Bureau of Mines Information Circular Nº 7012

FIG. 3.

greatest distance from the shaft is in the 200 ft. level northwest, which is in 1400 ft. and is still being driven. The 200-ft. level at this point is about 900 ft. below the surface.

Mine equipment consists of electric hoist, two Sullivan air compressors, motor driven, having a combined capacity of 2340 cu. ft. per minute; complete blacksmith shop, with Sullivan drill sharpener and automatic (hot lead) tempering machine; carpenter shop, machine shop and assay office. Two sinking pumps and a 3-in. centrifugal pump handle water to the 300 ft. level where a 350 g.p.m. triplex pump boosts it to the surface.

Flow sheet of the mill is printed herewith. Fig. 3.

The company employs 105 men.*

Bibl.: (Wilshire Bishop Creek Mine) State Mineralogist's Reports XV, p. 85; XVII, pp. 281-282; XXII, p. 474.

Cashier (Harrisburg Mine). The property comprises 7 claims situated in Wildrose Mining District, in the Panamint Range of mountains, 55 miles north of Trona and 9 miles south of Skidoo; elevation, 5000 ft.; owner, J. P. Augerebery, Trona, California; worked from 1906 to 1910 by the former owners; acquired by Cashier Mining Company of Los Angeles and operated until 1914; relocated by Augerebery. Ore-bearing fissures strike N. 20° E., dip 70° E., cutting beds of limestone. An intrusion of diorite, having a thickness of 100 ft., occurs on contact of limestone, with a general north and south strike. The ore, free-milling gold, occurs in an irregular lens-shaped body from 6 in. to 12 ft. in width in limestone.

Development: A 400-ft. incline shaft has been sunk on the orebody, and levels driven at 100, 200, 300 and 400 ft. The 100-ft. level is the main working level and connects with the surface at 350 ft. northeast of shaft. At 100 ft. from portal of tunnel cut fissure in limestone, which strikes N. 20° E., with drift north 120 ft. on fissure, and south 60 ft. Ore shoot developed was 100 ft. in length. At 350 ft. southwest of portal of tunnel, there is a drift driven S. 20° W., 450 ft. to incline shaft. At 400 ft. southwest of portal of tunnel there is a drift southwest 250 ft. on N. 20° E. fissure.

Estimated 3000 tons of ore on dump that is reported to carry $15 per ton in gold.

Recently some ore has been mined from tunnel level and hauled to mill of Journigan Mining & Milling Company for treatment. The mill is located at Emigrant Springs. Production $150,000.

Bibl.: State Mineralogist's Reports XV, pp. 75, 76; XXII, pp. 466, 467.

Cecil R. Mine. It comprises one claim situated on the west slope of the Panamint Range of mountains, 4 miles south of Ballarat; elevation 1250 ft.; owners, Edward Hague, M. J. Sherlock, Trona, California.

Bibl.: State Mineralogist's Reports XV, p. 76; XXVIII, p. 366.

Chloride Cliff Mine. It comprises six claims situated in Chloride Cliff Mining District, along the summit of Funeral Mountains, 18 miles

* Later: Development work having failed to show any new ore, the mine was shut down and pumps pulled in the fall of 1938.

southwest of Beatty, Nevada; elevation 5300 ft.; owners, Hiram P. Porter, S. Johnson, Louis McCrea, Beatty, Nev.

Five parallel quartz veins occur in limestone near contact of quartzite. These veins strike northeast and southwest. Widths vary from 2 to 4 ft. The vein quartz contains free gold associated with pyrite and galena. There are seven tunnels driven on the different veins, the longest being 400 ft., the others being about 100 ft. in length. The greatest vertical depth below outcrop being 800 ft. Under lease to Louis McCrea, Beatty, Nevada, from 1932 to 1936, who shipped about 30 tons of ore per month to smelters at Salt Lake City. In 1936 under option to Coen Companies, Inc., G. W. Coen, president, 610 South Broadway, Los Angeles, Calif., operated property to June 26th, 1937.

Bibl.: State Mineralogist's Report XV, pp. 76, 77; U. S. G. S. Bull. 285, pp. 72, 73.

Champion Group of Mines. It comprises 9 claims, situated 16 miles west of Shoshone, and 6 miles east of Confidence Mill, on the western slope of the Black Mountains; elevation 1500 ft., owners, S. M. Barber and F. M. O'Conner, of Los Angeles.

The orebodies are in quartzose schist, and the mineralization parallels the stratification in certain layers of the schist. The silicified schist carrying free gold dips 40° E., with a strike of N. 30° W. Veins vary from 2 to 4 ft. in width.

Bibl.: State Mineralogist's Report XXII, p. 468.

Cinnamon Mine. It is situated in the Beveridge Mining District, 10 miles northeast of Mount Whitney, a station on California-Nevada Railroad; elevation 6500 ft.; owners, F. M. Hess, and A. W. Hess, of Lone Pine, California.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 279; XXII, p. 467.

Cleveland Mine is in the Fish Springs Mining District, on the east slope of the granite hills, on the western side of Owens Valley, six miles south of Big Pine; owner, Mrs. Joseph Mear, Big Pine, California.

Under lease since August 1935 to T. L. Brite.

There are 7 claims known as Cleveland, Cleveland Fraction, Cleveland Extension, Gold Bug, United, United No. 4, and United No. 5.

A series of narrow, roughly parallel veins occur in the granitic country rock. The strike is a little east of north, dip from 15° to 30° NW. They vary in width from 6 in. to 12 in.

Development consists of about 50 tunnels varying up to 800 ft. in length. This work has been done on some 10 or 12 different veins. Principal development is on the Cleveland vein. On this vein a tunnel has been driven 800 ft. About 600 ft. from the portal it intersects an incline shaft from the surface. This shaft has been sunk 60 ft. below the tunnel giving it a total length on the dip of 560 ft. At the bottom, a drift has been driven southwest 100 ft. on a vein about 6 in. wide. This ore, as sorted and shipped, is said to contain from

3 to 11 oz. of gold per ton. The ore is shipped to the Tropico Mill near Rosamond.

Three men working.

Bibl.: State Mineralogist's Reports XVII, pp. 279, 280; XXII, p. 467.

Commetti Mine comprising 10 claims, including 3 millsites, is situated in the Fish Creek Mining District, six miles south of Big Pine, in the low granitic hills on the west side of Owens Valley; elevation 4500 ft.; owner, Commetti Mines Company, Alexander Richards, of Boston, Pres.; under lease to Ellis Rowe and W. B. Engle, of Pasadena, California.

Two parallel quartz veins occur in the granite. They are separated by an andesitic dike which is about 15 ft. thick. Strike of the veins is E.-W., dip 80° S. The average width of the vein is 4 ft. The center of the veins is filled with porphyry, with from 12 to 18 inches of quartz on each side. Mineralization consists of iron oxides, pyrite, some chalcopyrite and free gold.

Development consists of three tunnels, at different elevations and a winze 210 ft. below lower tunnel. The upper tunnel has been driven 300 ft.; the intermediate tunnel 536 ft. and the lower tunnel 450 ft. At 440 ft. from the portal of the lower tunnel a winze has been put down 210 ft. A drift was driven west 385 ft. on the 110-ft. level of this winze; at 256 ft. from the shaft a crosscut was driven to the hanging wall with a short drift east and a small stope above this drift. At the 155-ft. level a drift has been driven 70 ft. west. On the 210-ft. level a drift has been driven 270 ft. west on the north or footwall vein. The average width between walls of the vein is about 3½ ft. The ore in the vein is from 60 to 120 ft. west of the winze. On the lower level it is reported to have been sorted and shipped to the smelter yielding $70 per ton. On the south or hanging-wall vein a drift was driven 30 ft. east on 8 in. of ore which is reported to carry $8 to $13 per ton. There is a drift west on this vein 100 ft. At 30 ft. from the crosscut an incline winze has been sunk 50 ft. and 15 ft. further west a vertical winze was sunk to connect with the incline winze at the bottom. It is reported that 21 tons of ore, carrying $30 per ton has been shipped from these workings. The vein varies from 1 to 3 ft. in width, in the winze.

Two men are working, sinking incline winze.

Bibl.: State Mineralogist's Reports XVII, p. 280; XXII, p. 468.

Confidence Mine. It comprises several patented claims, situated 14 miles west of Shoshone, and 8 miles east of the Old Confidence Mill, on the western slope of the Black Mountains; elevation, 2500 ft. A series of parallel quartz veins occurs in a silicified hornblende schist. Veins trend N. 30° W., and dip 40° E. Widths vary from 2 to 6 ft.

Idle.

Coso Cyanide Plant. Cyanide plant at Coso; owned by Louis Wormken; operating on tailings from old arrastra ponds in the Coso District. Plant consists of a solution tank 3 ft. by 8 ft. by 3½ ft. deep and seven leaching tanks; six, 6 ft. in diameter, and one, 10 ft. in diameter, and all 4 ft. deep. Tanks are loaded from a one-ton Ford

dump truck and leached six days in a solution containing $2\frac{1}{2}$ lbs. of sodium cyanide per ton of water. Precipitation by zinc shavings in a zinc box containing five 14-inch cells. Solution from the zinc box flows to a sump tank and is pumped back into the solution tank. A fifty per cent recovery is claimed on six dollar heads. Capacity is $6\frac{1}{2}$ tons per 24 hours.

Two men are employed.

Coso View Mine. Situated in the Coso Mining District, 3 miles south of Cold Springs and adjoins the Mexican Mine on the north. Consists of one claim owned by M. D. Early and L. E. Early, of Lancaster, California, and C. H. Turner, of Las Vegas, Nevada. Developed by a vertical shaft 165 ft. deep with a 25 ft. crosscut east at 150 ft. depth. The shaft and crosscut were driven to explore a dike which samples $8 to $9 on the surface.

Idle.

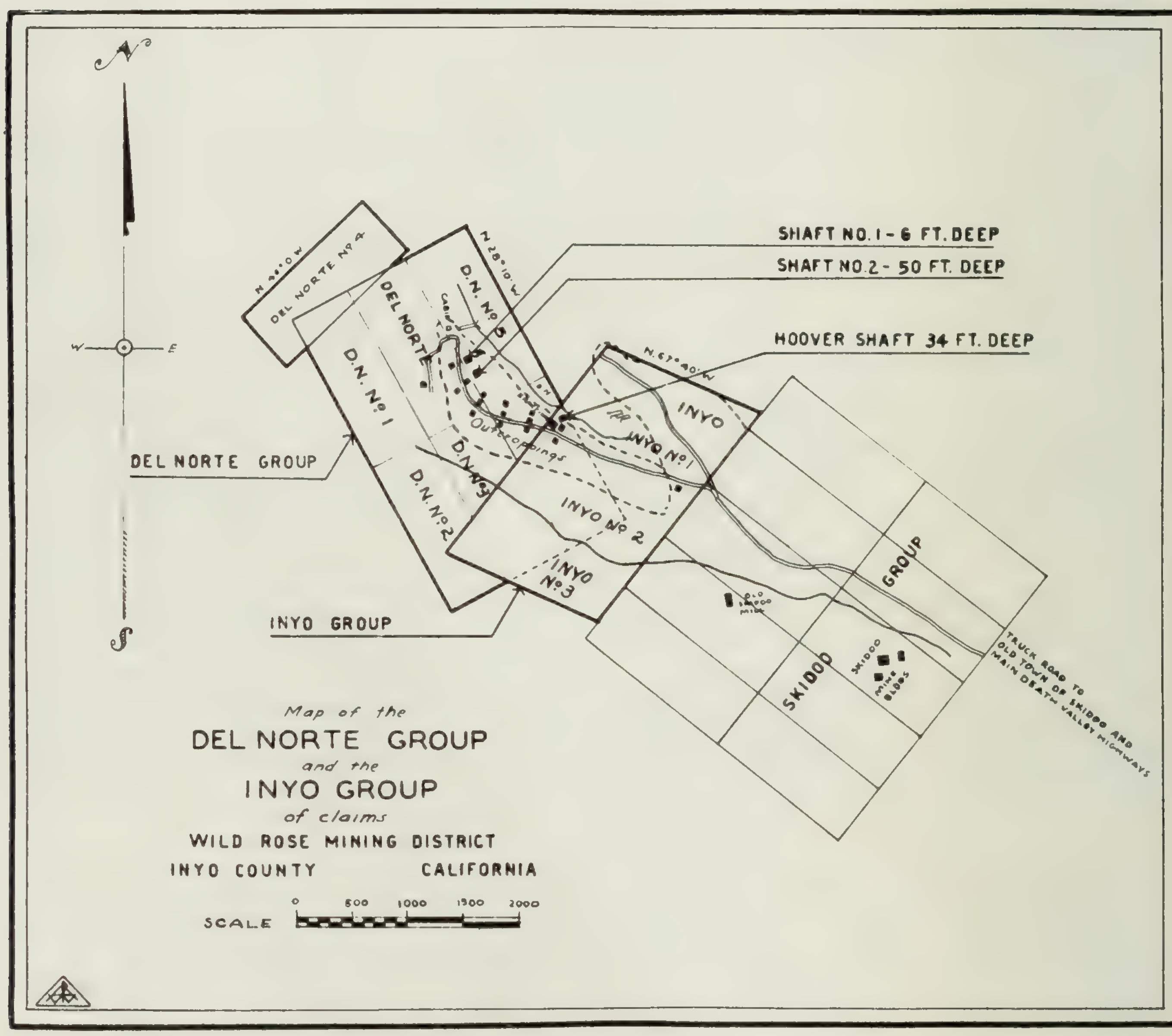


FIG. 4.

Curran Mine. Situated about half a mile northeast of Panamint townsite; is owned by Mrs. H. H. Thompson, of Ballarat.

Idle.

Bibl.: State Mineralogist's Report XXVIII, pp. 366, 368.

Del Norte Group of Mines. This property comprises 6 claims situated in the Wildrose Mining District, in the Panamint Range of mountains, 18 miles north of Wildrose Springs and 45 miles north of Trona;

elevation, 5300 ft.; owners, J. P. McCafferty, of Los Angeles, California; L. V. Howell, of Lone Pine, and James Stewart, of Darwin; under lease and bond to the *Panamint Milling Company;* Adolph Ramish, president; Roy C. Troeger, secretary and manager, 972 Fourth Ave., Los Angeles. (See Fig. 4.)

A massive bed of quartzite 25 to 30 ft. in thickness overlies quartz monzonite; general strike east and west, with a dip of 15 degrees north. The gold occurs in quartz along fractures in the quartzite. This quartzite bed is 500 ft. in width and 3000 ft. in length with an average thickness of 23 ft. Development consists of 10 shafts from 10 to 50 ft. in depth, and a number of trenches about 100 ft. in length, with a depth of 2 feet. There are 2 shafts 50 ft. deep, about 600 ft. apart. Samples cut at 5 ft. intervals in two 50 ft. shafts and along two trenches 100 ft. in length, were reported to have an average value of $6 per ton in gold. Several shipments of selected ore made to Burton Bros., Inc., Rosamond, California, were reported to have averaged from $16 to $25 per ton. In the quartz monzonite that underlies the quartzite bed, a series of quartz veins roughly parallel occur that have a general north and south strike with dips varying from 30° to 70° W.; widths, 12 in. to 2 ft. On one of these a tunnel has been driven SW. 160 ft. entirely in monzonite, the face of the tunnel being vertically below the east edge of the quartzite bed. Six men are employed on development.

Davenport Mine. This property comprises 6 claims, situated in the Argus Range of mountains, on the ridge between Homeward Canyon and Bruce Canyon, adjoining the Arando group of mines on the south, 12 mi. north of Trona; elevation, 4000 ft.; owner, Mrs. Nellie Bliss, Trona, California; under lease and bond to Clifford Burton, Rosamond, California; George Wyman, Trona, and N. W. Sweetzer, Trona, California. The vein strikes east and west, with a dip of 54° S.; width 6 to 20 ft. The vein filling is iron-stained porphyry with granite walls. Development consists of a vertical shaft 100 ft. deep, with crosscuts on the 50 and 100 ft. levels to the vein with about 500 ft. of drifts.

Six men are employed on development work.

Echo-G. H. Edge Group of 5 claims and 2 fractions, patented, is on the south side of Echo Canyon, on the west slope of the Funeral Mountains and the east side of Death Valley, about 12 miles east of Furnace Creek Ranch; elevation about 3000 ft.; owners, D. M. Coon, of Compton, California, and Frank McDonald, of Shoshone.

Country rock consists of limestone, quartzite and andesite. The quartz veins occur in the quartzite. There are three principal veins, strike E.-W., dip, 55° S., one cross stringer, strike NE., dip N. Widths vary from a few inches to 3½ ft.; principal values in gold up to $40 per ton.

Development consists of two shafts, 80 and 60 ft. deep, respectively.

Two men are working.

Emigrant Springs Mine (Saddle Rock). This property comprising 4 patented claims and 12 claims held by location is situated in the Wildrose Mining District, in the Panamint Range of mountains, on the ridge east of Emigrant Canyon, 5 miles southeast of Emigrant Springs, and 16 mi. south of Stove Pipe Wells; elevation, 4600 ft.; owners,

Emigrant Springs Mining Co.; H. W. Eichbaum, president; Mrs. H. W. Eichbaum, secretary, Stove Pipe Wells, Inyo County, California.

The quartzite bed overlies quartz monzonite; dip 15° northwest. This bed of quartzite has an average thickness of 25 ft. and the quartzite has been fractured in all directions. The fractures have been filled with quartz which carries values in gold. The quartzite, which occurs on the Pima and Golden Rule claims, is about 600 ft. in width and 3000 ft. in length. The gold values are reported to range from $4 to $6 per ton. Some very high-grade ore has been found along fractures on the surface. Development consists of three tunnels and five shallow shafts. No. 1 tunnel, located on the Pima Claim, is driven N. 40° E., as a crosscut for a distance of 90 ft. in quartz monzonite, and is 100 ft. below the quartzite bed. In the face of this tunnel, cut a vein of quartz in the monzonite which strikes N. 30° W., dip 15° E., width 2 feet. About 400 ft. south of No. 1 tunnel, No. 2 tunnel is driven as a crosscut N. 50° E., 90 feet. At 45 ft. from the portal, cut a quartz vein in the monzonite, which strikes N. 60° W., dip 45° S. A drift has been driven on this vein for a distance of 50 feet. The vein has a width of 4 ft. and is mineralized with pyrite. On the south end of the property, where the quartz monzonite is exposed on the ridge, a number of shafts have been sunk on parallel veins to depths of 20 to 70 feet.

The property has potential possibilities as a large low-grade gold deposit, and all prospecting work should be confined to quartzite to determine the average value of the ore.

Idle.

Eureka Mine. It is situated on East side of Owens Valley at the foot of the Inyo Mountains, nine miles northeast of Independence; elevation 4000 ft. The property consists of 4 patented claims. A granite mass, cut by numerous quartz stringers, lies between two dikes of diorite porphyry. The ore is highly oxidized, containing much red and brown iron oxide, with copper silicate (chrysocolla). The oxidized ore shows coarse gold. Development consists of tunnel 100 ft. in length and shaft 100 ft. in depth.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 469; U. S. G. S. Bull. 540, pp. 115, 116; U. S. G. S. Professional Paper 110, p. 120.

Gold Basin Mine. It comprises 7 claims, situated in Argus Mining District, in the Argus Range of mountains, south of Mountain Springs Canyon, 25 miles northeast of Brown; elevation 6000 ft.; owners, J. H. Allen, of Brown, and E. A. Green, of Los Angeles.

A quartz vein occurs along an andesitic-porphyry dike in granite, which strikes NW. and SE. Width 12 in. to 2 ft. Development consists of number of shallow shafts and open cuts. Two men are employed on development.

Gold Bug Mine. Formerly Anthony Mine and originally known as Post Office Springs Mine, comprising 5 unpatented claims, is on the south side of Pleasant Canyon, 2 miles west of the Radcliff Mill and about 4 miles east of Ballarat; elevation at the mine, 4200 ft.; owner, Mrs. Ada Norris, Box 443, Trona, California.

This property was fully described in our Report XXVIII, p. 368.

Gold Hill Mine. It comprises 4 patented claims, on the east slope of the Panamint Mountains, some 12 miles south of Bennett's Well and just east of Butte Valley; elevation 5400 ft.; owners, Fred W. Gray, 3503 McClintock Avenue, Los Angeles, California, and Wm. Hyder, Trona, California.

Bibl.: State Mineralogist's Report XXVIII, p. 369.

Gold Ridge Group of Mines. The property comprises 20 claims, known as the Gold Ridge, Iron Mask, Gold Point, Goodrich, and Old Mexican groups of claims, situated in the Coso Mining District, 20 miles west of Darwin; elevation, 4200 to 5000 ft.; owner, Western Consolidated Gold Mines, Inc.; R. L. Tuttle, president; A. R. Moore, secretary, Los Angeles, California. A series of parallel north and south veins occur in granite. Width of the veins vary from 12 in. to 2 ft.; developed by shafts from 50 to 100 ft. in depth.

Idle.

Gold Spur Mine (Lestro Mine). It comprises 16 claims known as Lestro No. 1 to No. 8, and Caliente No. 1 to No. 8, situated on ridge between Coyote and Goler canyons, in the South Park Mining District, 16 miles southeast of Ballarat; elevation 2200 to 4000 ft.; owners, James Lester and J. J. Rogers, Los Angeles.

Two vein systems occur in gneiss. One consists of a series of parallel veins which strike N. 15° E. Widths vary from 2 to 4 ft. The veins are cut by an andesite dike that strikes N. 48° W. Near the center of Caliente No. 4 Claim, there is a showing of ore on the andesite dike 200 ft. in length. Samples taken across dike are reported to assay from $4 to $40 per ton in gold. The other vein system consists of a series of parallel veins that strikes N. 70°–80° W., dips S. 70°; widths 2 to 4 ft.

Samples taken from workings on the different veins of this system are reported to assay from $8 to $20 per ton in gold.

Development consists of opencuts and tunnels on different veins. Tunnels vary from 50 to 160 ft. in length; one shaft 50 ft. deep. The owners are planning to drive a tunnel 900 ft. in length on andesite dike, with backs of about 600 ft.

Idle.

Bibl.: State Mineralogist's Reports XV, pp. 77, 78; XII, p. 469.

Gold Standard Mine. It comprises 34 claims, situated on the east slope of the Inyo Range of mountains, west of Saline Valley, in the Beveridge-Ubehebe Mining District, 60 miles northeast of Olancha. The property extends from Little Hunter Canyon on the north to and across Craig Canyon on the south; elevation, 5000 to 6000 ft.; owner Gold Standard Mining Company; Col. A. E. Monteith, president and manager, Olancha, California.

The two principal mineral deposits consist of two quartz veins in quartz-monzonite. On the south end of the property, there is a quartz blow-out, about 50 ft. in width, and exposed on the surface for a distance of 150 ft. in length. The strike is NE.-SW. The vein quartz is mineralized with malachite, azurite, tetrahedrite, chalcopyrite, galena, hematite, pyrite, and sphalerite; developed by open cut. The principal vein, known as Gold Standard vein, occurs along a fault, on

contact of dolomite and quartz-monzonite; strike NW.-SE.; dip, 78° SW.; width 4 to 11 ft. The vein can be traced on the surface for a distance of 2100 ft., of which 1200 ft. lies along the limestone contact; developed by 4 tunnels, the longest being 150 ft. Several shipments of sorted ore to smelters at Salt Lake City, Utah, carried 3 oz. in gold, 58 oz. in silver, and 11% copper. Six men are employed.

Gold Tooth Mine. It comprises 2 claims, situated on the west slope of the Panamint Range, 10 miles south of Ballarat; elevation, 1400 ft.; owners, A. R. Greenslitt and R. E. Baughman, Trona, California; under lease to Joseph Horn, Glendale, California.

Bibl.: State Mineralogist's Report XXVIII, pp. 369, 370.

Gold Wedge Mine. It comprises 8 claims, situated in the Pine Mountain District, on the divide between Wyman Creek and Birch Creek, 1¾ miles south of Roberts Ranch, 9 miles north of Deep Springs Ranch and 20 miles northeast of Big Pine; elevation, 8000 ft.; owner, A. T. Wilkerson, Bishop, California.

The mineralization occurs in a belt of schist which strikes northeast and southwest. The schist belt is about 300 ft. in width. The ore occurs in stringers of quartz along joint planes in schist. The ore mineralization extends from 2 to 6 ft. in width in the silicified schist. Developments consist of the east shaft which has been sunk to a vertical depth of 65 ft. On the 45-ft. level there is a drift west 122 ft. connecting with an incline shaft which is 130 ft. deep. Between these shafts for a distance of 55 ft., the silicified schists are reported to have an average value of $7 per ton in gold. Ore mined along joint planes is reported to carry $20 per ton in gold. Mill equipment consists of 6 in. by 8 in. crusher, Challenge ore feeder, five 600-lb. stamps, amalgamation plates (2 ft. wide by 16 ft. in length), Overstrom concentrator. The mill is driven by a 12 hp. Fairbanks-Morse gas engine.

Two men are employed.

Golden Eagle Mine. It is situated in the Beveridge Mining District, 10 miles northeast of Owenyo, a station on the California and Nevada Railroad; owner, John C. Anton, of Lone Pine, California.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 78; XXII, p. 469.

Golden Rod (Marigold) Mine. It is situated in the Coso District, 7 miles south of Darwin on the east slope of the Coso Mountains, at an elevation of 6000 ft.; L. W. Lee, of Darwin, owner. The vein is 6 in. to 4 ft. wide, in granite; strikes E. and W. and dips about 35° S. Principal development is by three tunnels driven west: No. 1, 100 ft.; No. 2, 300 ft., and No. 3, 350 ft. long. There is a 100 ft. vertical interval between tunnels No. 1 and No. 2, and a 200 ft. interval between tunnels No. 2 and No. 3. At 100 ft. west of the portal of tunnel No. 2 the vein is stoped for a distance of 50 ft. and for a height of 100 ft. Ten tons shipped to the Jones Mill at Hughes Lake in 1937 are reported to have assayed $35. There are about ten tons piled on the dump which will be milled at Coso.

Bibl.: State Mineralogist's Reports XV, p. 82; XXII, p. 471.

Golden Treasure Mine (see Ashford Mine).

Gypsy Queen Mine, consisting of 10 claims is on the west slope of the Inyo Mountains, 2½ miles south of Aberdeen, a station on the Southern Pacific R. R. and 4 miles east of the Owens Valley highway; elevation, 4300 ft.; last known owner, Frank Thomas, Big Pine, California.

Here a series of parallel veins, with connecting quartz stringers, occur in a block of quartz-monzonite which lies between two diorite dikes. They strike N. 10° W., to N. 30° W., dip about 80° E. The widths vary from 3 in. to 8 ft. Vein filling is quartz which carries chalcopyrite, chrysocolla, hematite and some free gold. Development consists of 4 tunnels about 80 to 200 ft. in length and a shaft 40 ft. deep. The vein in the shaft is about 3½ ft. wide and is reported to carry good values.

Idle.

Bibl.: State Mineralogist's Reports (Eureka) XV, p. 77; XXII, p. 469; U. S. G. S. Bull. 540, pp. 115, 116.

Harrisburg Mine. It is situated in the Wildrose Mining District, in the Panamint Range of mountains, adjoins the Cashier Mine and is 55 miles north of Trona, California; elevation, 5000 ft.; owner, J. P. Augerebery, Trona, California.

Bibl.: State Mineralogist's Reports XV, p. 79; XXII, p. 469.

Highland Chief Mine. It comprises two claims situated in the Beveridge Mining District, on the east slope of the Inyo Range of mountains, about 2 miles north of Beveridge Canyon on the trail to Keynote Mine; elevation, 6000 ft.; owner, Thomas Hancock, of Lone Pine, California.

Quartz vein in granite, strike NW. and SE., dip 50° NE.; width, 12 in. to 2 ft. Development consists of a tunnel 100 ft. in length. Mill equipment consists of a 6 in. by 8 in. Blake crusher and a Moyle one-stamp mill.

Idle.

Holy Roller Mine. It is situated in the South Park Mining District on the west slope of the Panamint Range of mountains, 25 miles northeast of Trona; owner, A. C. Porter, of Trona, California. Idle.

Bibl.: State Mineralogist's Reports XV, p. 79; XXVIII, p. 370.

Hornspoon Mine. It is situated near the head of Hall Canyon, 10 miles northeast of Ballarat; elevation, 7500 ft.; owner, Christopher Wicht, Ballarat, California.

Idle.

Bibl.: State Mineralogist's Report XXVIII, p. 370.

Inyo Gold Mine, comprising 17 patented and 5 unpatented claims, is situated in Echo Canyon, on the west slope of the Funeral Mountains, in the east side of Death Valley, 10 miles from the highway to Death Valley Junction and 12 miles east of Furnace Creek Ranch; elevation, 3900 to 4400 ft.; owner, *Inyo Consolidated Mines, Inc.;* F. M.

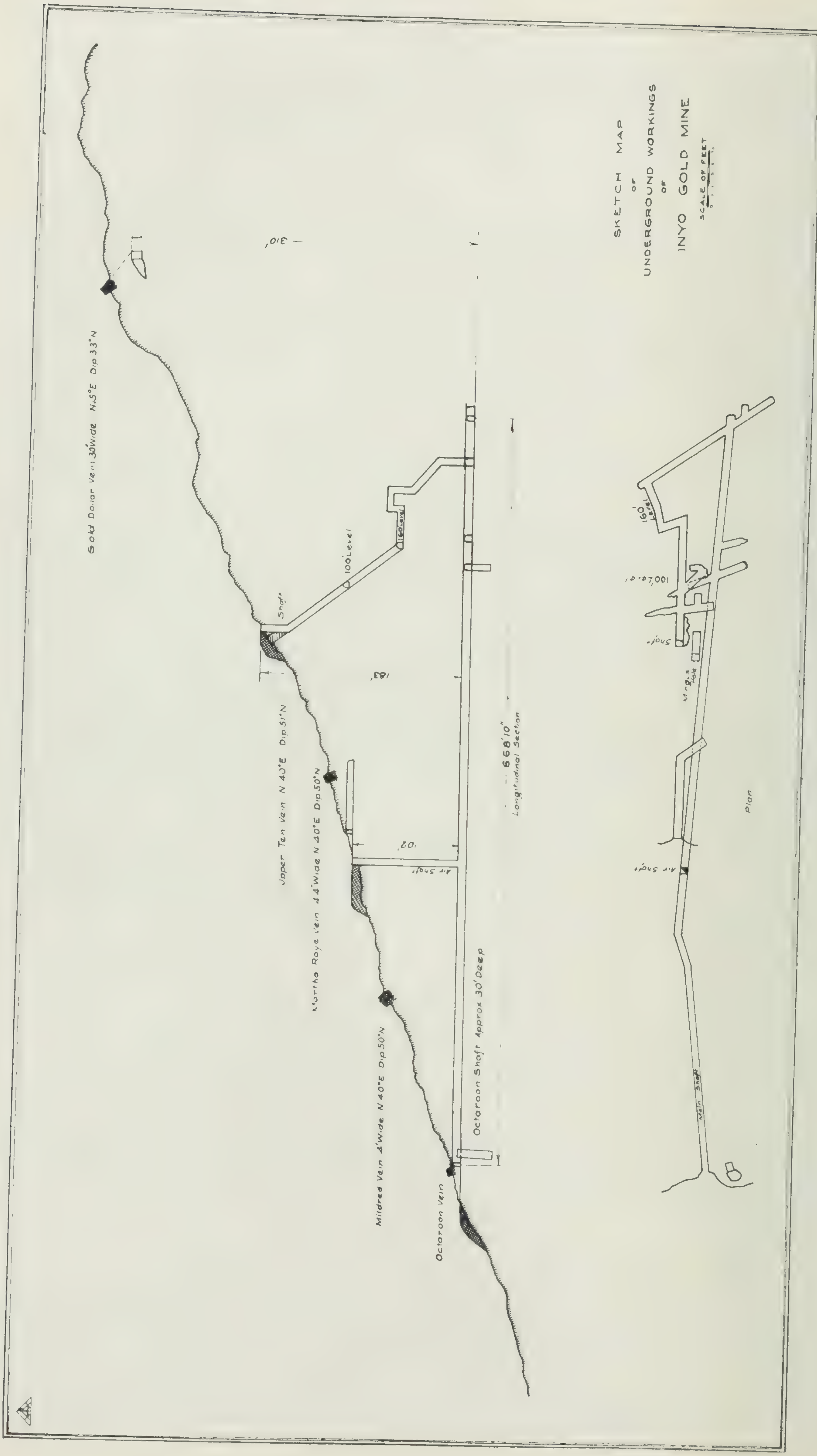

SKETCH MAP
OF
UNDERGROUND WORKINGS
OF
INYO GOLD MINE
SCALE OF FEET
Gold Dollar Vein 30' Wide N.5°E Dip 33°N
310'
Shaft
100 Level
160 Level
183'
Martha Roye Vein 4.4' Wide N 40°E Dip 50°N
102'
Air Shaft
668'10"
Longitudinal Section
Mildred Vein 4' Wide N 40°E Dip 50°N
Octoroon Vein
Octoroon Shaft Approx 30' Deep
160' Level
100 Level
Shaft
Air Shaft
Main Shaft
Plan

FIG. 5.

Gallaher, president; Stanley Hollister, secretary, 830 State Street, Santa Barbara, California.

The country rock is quartzite and schist. Six quartz veins have been found in the quartzite. Their general strike is NE.-SW., dip from 35° to 55° NW.; widths vary from 12 in. to 15 ft. or more. The quartz is lenticular in shape and neither the length nor the average width of the lenses has been determined. Mineralization consists of oxides of iron and manganese, with which is associated free gold, usually in a finely divided state.

The principal development is on the Upper Ten Claim. It consists of an inclined shaft, 220 ft. long, which connects with a tunnel at the bottom. Levels have been driven at 100 and 160 ft. horizons, 60 and 40 ft., respectively. The tunnel was driven as a crosscut north 695 ft. to the vein, drift east 50 ft. and 80 ft. west to connect with the shaft. At about 200 ft. from the portal an air shaft was raised through to the surface, a distance of 80 ft. At the collar of the air shaft a crosscut has been driven north 50 ft. where it intersected another vein about 10 ft. wide (where cut); strike N. 50° E., dip 45° NW. It is filled with porous quartz and is said to carry $25 per ton in gold. They have drifted northeast 25 ft. on this vein. About 50 ft. east of collar of the main shaft a crosscut exposes the vein for a width of 30 ft., which is said to be good ore. (See Fig. 5.)

At the top of the hill, to the north of these workings another vein outcrops for a length of about 300 ft. with an average width of about 3 ft. No work has been done on this as yet.

A small mill has been erected at the camp, consisting of the following: 50-ton bin, 6 by 10 jaw crusher to 30-ton bin, reciprocating feeder to 3 ft. by 6 ft. ball mill to plates and 2 Simpson tables, drag classifier for dewatering: capacity, 25 tons per day. Water is hauled from the valley for the mill. Eight men are employed.

Ironsides Mine. (See Burgess Mine.)

Josephine Mine consists of 3 claims situated in the Coso Mining District, about 8 miles southwest of Darwin; L. D. Owen, of Darwin, owner.

This mine was idle for many years until 1937 when it was leased by the *Coso Mining and Milling Company*, who subleased it to G. N. Sackett. About 100 tons were mined from a drift off a raise 60 ft. above the lower tunnel. Ten tons shipped to Hughes Lake are reported to have averaged $40 per ton, and 20 tons shipped to the Keeler Gold Mine, $26 per ton.

Idle.

Bibl.: State Mineralogist's Reports XII, p. 138; XIII, p. 181.

Journigan's Custom Mill. It is situated at Emigrant Springs in Emigrant Canyon, in the Panamint Range of mountains, 4 miles west of Skidoo Mine, and 25 miles northeast of Darwin; elevation, 4045 ft.; owner, Roy Journigan, Trona, California.

Capacity of plant is 40 tons per 24 hours. Ore being milled is hauled by truck from Skidoo and Cashier mines.

Journigan's Group of Mines. It comprises 5 claims, adjoining the Big Horn Mine on the west, situated in the Beveridge Mining District,

13 miles northeast of Lone Pine; elevation, 7000 ft.; owner, Roy Journigan, Trona, California.

Quartz vein, in granite, strikes E. and W., dip 80° N.; width 3 ft. Ore shows free gold associated with pyrite and chalcopyrite. Development consists of a tunnel driven west 150 ft. on the vein; ore shoot developed in a tunnel 30 ft. in length, with an average width of 3 ft.; ore stoped 30 ft. above the tunnel level.

Idle.

July Group of Mines. It comprises 2 claims, situated in the Grapevine Mining District, on the east slope of the Grapevine Range of mountains, near the boundary line of California and Nevada, 26 miles northwest of Beatty, Nevada, and 22 miles west of Springdale, Nevada; elevation, 6400 ft.; owner, Charles Phinney, of Beatty, Nevada; under lease and bond to E. W. Batchman, Fort Worth, Texas; Sol Camp, superintendent.

The ore occurs along fault fractures in rhyolite. These fractures strike N. 10° E., dip 60° E.; widths 6 ft. to 30 ft. The vein material is silicified rhyolite showing free gold, with values varying from $5 to $25 per ton in gold. Development consists of tunnel driven S. 74° W., 85 ft. in length with winze sunk from tunnel level to depth of 50 ft. then drift from bottom of winze 30 ft. N. 10° E., in ore. Six men employed on development work.

Jumbo Mine. It comprises 6 claims west of the Black Eagle mine, on the west flank of the Inyo Range of mountains, 4 miles east of Kearsarge; elevation 8000 ft.; owner, Clarence Johnson, Independence, California.

Idle.

Bibl.: State Mineralogist's Report XXII, pp. 469, 470.

Keane Wonder Mine. This property comprises 26 patented claims located in Sec. 6, T. 29 N., R. 1 E., Sec. 31., T. 30 N., R. 1 E., on the west slope of the Funeral Range of Mountains, 22 miles west of Rhyolite; elevation, 3400 ft.; owners, Coen Companies, Inc.; G. W. Coen, president, 610 South Broadway, Los Angeles; under lease and bond to the *Black Mammoth Cons. Mines;* Fred A. Volmer, president, Silver Peak, Nevada; A. N. Sweet, superintendent.

The property was operated by Keane Wonder Gold Mining Company from 1908 until May, 1916, when operations were suspended, as the developed orebodies were worked out. The country rock consists of mica and hornblende-schists and granite, with a limestone capping 150 ft. to 300 ft. in thickness. Intrusions of diorite and granodiorite dikes cut the schists, and along these intrusive dikes occur ore depositions. The dikes and ore-croppings can be traced on the surface for a distance of 2000 ft. Strike N. 25° W., dip 20° E. The orebodies occur as lenticular masses varying in thickness from 5 to 25 ft. and from 100 to 300 ft. in length. The quartz is iron-stained carrying fine gold, associated with galena and pyrite. The development consists of seven crosscut tunnels and a shaft 200 ft. deep. There are over 5000 ft. of underground workings; stoped from 180-ft. tunnel level to surface. The following is a record of production from 1908 to 1912:

1908 mined and milled 17,711 tons of ore, from which recovered $147,585.61 in bullion.

1909—20,222 tons of ore, recovered $196,600.94.
1910—20,500 tons of ore, recovered $180,942.82.
1911—15,552 tons of ore, recovered $161,080.32.
Grand total, 73,989 tons of ore, recovered $682,209.69.

The average value of ore treated was $9.22 per ton in gold, recovery was 93% of the assay value of the ore. Costs of mining and milling were $4 per ton. Total production of the property is reported to have been $1,100,000.

Bibl.: State Mineralogist's Reports XV, pp. 79, 81; XXII, p. 470.

Kearsarge Mine. It is situated in the Kearsarge Mining District, on east slope of the Sierras, at an elevation of 8000 to 9000 ft. The

PHOTO. 4. Keeler Gold Mine and Cyanide Plant, Keeler Gold Mining Co., Keeler, Inyo County.

vein, which is a few feet wide, occurs in quartz-monzonite in proximity to a schist belt that is extensively penetrated by quartz monzonite and aplite dikes. The vein quartz is milk-white in color, rich in free gold and native silver. The vein strikes NE.-SW., dips 80° W. Development consists of a tunnel 250 feet in length; some shallow shafts and short tunnels.

Idle.

Bibl.: State Mineralogist's Reports VIII, pp. 232, 233; XVII, p. 280; XXII, p. 470; U. S. G. S. Professional Paper 110, p. 124.

Keeler Gold Mines, Inc., has 23 claims on the west slope of the Inyo Mountains, 4 miles southeast of Keeler; elevation about 4000 ft. Adolph Ramish, of Los Angeles, is president; Roy C. Troeger, 972 Fourth Avenue, Los Angeles, is secretary of the company.

The vein in limestone, strikes a little west of north and dips 70° W. The ore-shoot rakes to the north or it may be cut off along the intersection with a fracture having approximately the same strike but which

dips 40° W. Vein-filling is silicified wall-rock mineralized with oxides of iron and manganese which carry some free gold.

Property is developed by 250-ft. vertical shaft with levels at 70, 130 and 250 ft. On 70-ft. level, drift 160 ft. northwest; on 130, drift 550 ft. northwest; on 250, drift 350 ft. On the 130 level at 400 ft. north of the shaft, a cross-cut was driven east 120 ft. On the 250, at about 250 ft. from the shaft, a winze was sunk 155 ft. on a 40° inclination to the north. The vein in this winze was 4 to 7 ft. wide but apparently was cut off at the bottom by the fracture mentioned above.

The ore-shoot approximately 160 ft. long has been stoped from the 250 level to within about 70 ft. of the surface. This ore is reported to have averaged $9.40 per ton in gold. Mine equipment consists of electric hoist, 220 cu. ft. compressor, blacksmith shop, change house, etc

The mill has 3 receiving ore bins, 40 tons each, from these to jaw crusher, elevator, through Vezin sampler to 180-ton bin, belt feeder to 4 by 5 ft. ball mill, where it is ground in 2 lb. per ton cyanide solution. Ball mill is in closed circuit with duplex Dorr classifier, overflow to Dorr thickener, thence to 3 agitators in series to three 30-ft. diameter by 10 ft. deep Dorr thickeners. Precipitation is in two 6-compartment zinc boxes. Precipitates are melted in a tilting furnace; capacity, about 50 tons.

Ores from Coso, Skidoo and Wildrose districts were also treated in this mill.

Idle.

Keynote Mine (Golden Princess). This property comprises 7 claims, situated in the Beveridge Mining District, on the ridge north of Keynote Canyon in the Inyo Range of mountains, 12 miles northeast of Owenyo on the Southern Pacific Railroad; elevation, 8000 ft.; owner, *Golden Princess Mining Company;* Jules Canterno, president; F. G. Pauch, vice president; Glenn Tinder, secretary and treasurer; offices, Lone Pine, California.

Two veins occur in granite, known as the War Eagle and Keynote, which are 600 ft. apart. The Keynote vein strikes NW.-SE.; dip 35° W.; width, 2 to 4 ft. War Eagle vein strikes N. 20° W.; dip, 40° SW.; width, 4 ft.

The principal development work has been on the Keynote vein which has been developed by 7 tunnels at different elevations.

The main workings are from tunnels No. 7 and No. 9.

No. 5 tunnel	150 ft.
No. 6 tunnel	300 ft.
No. 7 tunnel	750 ft.
No. 8 tunnel	300 ft.
No. 9 tunnel	600 ft.
No. 10 tunnel	225 ft.
No. 14 tunnel	205 ft.

There are five tunnels on Keynote vein and three on War Eagle vein. No. 6 tunnel on Keynote vein is 300 ft. in length, driven northwest.

There is a stope 150 ft. in length from this tunnel level, and stoped to the No. 5 tunnel level, a distance of 50 ft. on inclination of the vein. No. 7 tunnel level is driven northwest 750 ft.; at 50 ft. from portal cut first shoot of ore. The ore was stoped for a length of 250 ft. with an average width of 4 ft. to No. 6 tunnel level, a distance of approximately

100 ft. The vein quartz is mineralized with free gold, associated with pyrite and chalcopyrite. No. 9 tunnel level caved near portal.

War Eagle Vein. Upper tunnel driven N. 20° W. 240 ft. Two ore-shoots were developed in these workings. Each shoot has a length of 60 ft. with an average width of 4 ft. Ore is reported to have had an average value of $20 per ton.

Intermediate tunnel is 100 ft. in length and lower tunnel 120 ft. in length. Estimated tonnage of ore dump below No. 9 tunnel level is approximately 20,000 tons, reported to have an assay value of $8 per ton. Ore mined from the property was formerly milled in a 5-stamp mill located in Beveridge Canyon. The mine was operated continuously from 1878 to 1894 with a production of $500,000.

Idle.

Bibl.: State Mineralogist's Reports XII, p. 138; XIII, p. 181; XV, p. 81; XXII, p. 470. Register of Mines, Inyo County; Report of the Director of the Mint upon production of Precious Metals in U. S., 1883, p. 159; U. S. G. S. Bull. 540, p. 112.

Last Chance Group of Mines. It comprises 10 claims located on the west slope of the Black Mountains, 16 miles west of Shoshone; elevation, 1500 ft.; owners, L. V. Twining, R. C. Coryell, and S. M. Basher, of Los Angeles.

A quartz vein occurs in schist, strike N. 30° E., and dip 40° SE. The vein has a width of 12 in. to 2 ft.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 470.

Little Mack Mine. It comprises one claim and millsite, situated in the Modoc Mining District, adjoining the Minnietta mine on the south-east and is on the east slope of the Argus Range of mountains, 30 miles north of Trona; elevation, 3000 ft.; owner, Otto Siedentopf, Trona, California.

Three parallel diabase dikes cut the limestone beds. These dikes strike N. 60° W.; dip 60° S. The above-mentioned dikes are about 60 ft. apart.

A series of parallel quartz veins follow the bedding planes of the limestone. These veins strike N. 20° E., and dip 50° S., vary in width from 2 ft. to 4 ft. and carry values in gold associated with lead-carbonate. Short ore-bodies are found on intersections of quartz veins with diabase dikes. Development consists of a tunnel driven N. 70° W. 250 ft., following one of the diabase dikes. At 75 ft. from the portal, cut quartz vein carrying values in gold. Also, at 200 ft. west of the portal, cut another quartz vein carrying gold values. A raise was put up on the vein some 30 ft. and a small stope started. At 250 ft. west of the portal, a crosscut has been run north 55 ft. intersecting a parallel diabase dike. On the hill above the tunnel level, a tunnel has been driven S. 20° W. on a quartz vein in limestone, a distance of 20 ft., then an incline shaft sunk on the vein to a depth of 80 ft. The vein developed had an average width of 4 ft. with gold values stated to be $15 to $20 per ton. Ore mined from the tunnel level is transported by an aerial tram line 325 ft. in length to a 20-ton

ore bin. From the bin the ore goes to one 800-lb. stamp with amalgamation plate. Stamp is driven by a gas engine. Mine equipment consists of Rix compressor; blacksmith shop; and mine cars. Production is $15,000.

One man is employed.

Lost Burro Mine. It is situated in the Ubehebe District, 55 miles southwest of Bonnie Claire, Nevada; elevation, 5350 ft.; owner, Lost Burro Mining Company, Los Angeles; W. H. Blackmer, president.

Idle.

Bibl.: State Mineralogist's Reports XV, pp. 81, 82; XXII, pp. 470, 471.

Lucky Bill Mine. It comprises 3 claims situated on the east slope of the Sierra Nevada Range, on ridge west of Pine Creek, and 20 miles by road west of Bishop; elevation, 8000 ft.; owners, E. R. Elliott, George Cross and A. W. Hass, of Bishop, California.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 471.

Lucky Boy prospect, comprising 8 claims, is on the east slope of Black Mountain, about 12 miles northwest of Independence; elevation, 9000 ft.; owner, Geo. V. Parker, Independence, California.

The country rock is granodiorite, which is cut by a series of north-south diorite dikes. A series of northeast-southwest veins occur in these rocks, dip 65° to 70° NW. The veins are quite narrow and values are erratic.

Development consists of a 50 ft. tunnel.

Idle.

Lucky Red Mine. Located in the Coso Mining District, 5 miles east of Cold Springs; Inez J. MacConnell, owner. A 4-ft. quartz vein in diorite strikes northeast and dips 20° S. Assays average $3.60 in gold and carry from ½ to 1½% copper. A 3-in. stringer in the hanging wall is said to average $45 in gold. Developed by 150 ft. of trenching and three shafts from 8 to 16 ft. deep.

Luella Mine (formerly Abe Lincoln), consisting of 4 claims, is on the east slope of the Alabama Hills, 5 miles by road northwest of Lone Pine; elevation, about 4500 ft. One claim is leased from Mrs. Edwards, of San Clemente, Califoronia, and three held by location by the Luella Mining Company; J. G. McDonald, president, Ventura, California.

The company has a millsite, 3 miles north of Lone Pine and one-fourth mile west of the highway.

Here veins occur on the foot and hanging walls of a felsite dike in the granitic country rock. The strike varies from N. 30° W. to N. 10° E.; the dip changes in a vertical distance of five feet from 40° E. to 65° W. In the dike, which is some 8 ft. wide, there are horizontal joints from wall to wall which are mineralized. These joints are from 3 in. to 5 in. apart and from one in. to 3 in. wide. Vein-filling is largely quartz mineralized with hematite, copper-silicate,

pyrite and some free gold which is associated with hard, reddish-black bands of hematite.

Development consists of several tunnels, the upper ones driven years ago. Principal development consists of two tunnels about 75 ft. apart, vertically. The upper one was driven northwest about 350 ft. on the vein. There is some stoping on shoots apparently about 30 ft. long. The lower tunnel is 460 ft. long. At 210 ft. there is a 35-ft. winze and at 385 ft. there is a 35-ft. winze. There is a stope to the upper tunnel about 120 ft. long; average width approximately 3 ft. This stoping was done years ago and the grade of the ore is not known.

Idle.

Bibl.: State Mineralogist's Reports XII, p. 139; XIII, p. 182.

Magpie Group of Mines. This property comprises 5 claims, situated near Whippoorwill Flat, about $3\frac{1}{2}$ miles north of Waucoba Springs, and 29 miles southeast of Big Pine; owner, C. C. Cunningham, Los Angeles.

Two systems of quartz veins occur in limestone; north and south veins, and east and west veins. The quartz veins vary from 18 in. to 2 ft. and vein quartz shows gold associated with galena. Ore is reported to carry from $3 to $20 in gold, with 10 to 20 oz. in silver, and from 3% to 10% lead.

Development consists of shallow shafts 20 ft. in depth.

Idle.

Mamie Mine comprises 4 claims, including one placer claim, the Coso Maid placer, and the Coso Boy quartz claim, located in the Coso Mining District, two miles northwest of Coso; owned by E. M. Lorenz, of Coso.

The Coso Boy Claim has a shaft 18 ft. deep which was sunk to pick up an east-dipping vein showing on surface. Mr. Lorenz is operating a 3-ft. Chilean mill, grinding to 40-mesh and concentrating in a 20-in. Australian spiral pan concentrator. Power is furnished by an Austin motor. He is working on float ore and material obtained from old dumps in the vicinity.

Mammoth Mine. It comprises 7 claims situated in the Argus Mining District on ridge north of Mountain Springs Canyon, and 24 miles northeast of Brown; elevation, 5000 ft.; owners, M. V. Carr and Earl Carr, of Long Beach, California.

A quartz vein occurs in granite, strikes E.-W.; dip, 70° S.; width, 4 ft. The vein quartz is mineralized with hematite, pyrite and chalcopyrite. Development consists of two tunnels; the upper tunnel is driven west 320 ft. and at 300 ft. intersected ore. A winze has been sunk on the vein to a depth of 30 ft. and a raise put up 30 ft. About 400 ft. in elevation below these workings, a crosscut tunnel has been driven N. 10° W. 1000 ft. to intersect the vein. Equipment consists of a Gardner-Denver compressor driven by a 20 hp. gas engine; and a three-stamp mill.

Idle.

Marble Canyon Placers. These gold placer deposits occur along Marble Canyon, on the east slope of the Inyo Range of mountains,

in T. 10 S., R. 37 E., M. D. M., 23 miles southeast of Big Pine, on the Saline Valley-Waucoba Road; elevation, 7000 ft.

The channel on which the above locations have been made is about 200 ft. in width and 9 miles in length, and the general course of this channel is east and west. Bedrock is limestone and schist. The gravel is well-rounded and is made up of quartzite, granite and quartz. The gold occurs on bedrock and is fairly coarse in size, ranging from the size of wheat grains to nuggets. Development consists of several shafts sunk to bedrock with depths ranging from 70 to 115 ft. The principal drawback in working these placers is the lack of water, and the recovery of the gold is made by operation of dry placer machines.

In 1934 J. C. Lewis discovered some coarse gold in gulches on the ridge north of Marble Canyon, just east of the Waucoba-Saline Valley Road, and with dry washers recovered considerable gold. Following this discovery, a number of locations were made by J. C. Lewis, Frank Bedell and David T. Bedell. The following placer mines are under operation:

Anderson Group of Placer Claims. This group comprises 4 placer claims, situated in Marble Canyon, about 1½ miles east of the Bedell Group of Claims, 23 miles southeast of Big Pine; owner, Helah Anderson, of Big Pine; elevation, 5800 ft.

Two men are employed in sinking an incline shaft; present depth, 75 ft. The general course of the channel is east and west; width, 100 ft.

Bedell Group of Mines. It comprises 2 claims, situated in Marble Canyon, in T. 10 S., R. 37 E., M. D. M., 23 miles southeast of Big Pine; elevation, 6000 ft.; owners, David T. Bedell and Stuart Bedell, of Big Pine, California.

The course of the channel is east and west, with 2400 ft. on the channel. Width of the pay gravel is 15 ft. The pay gravel is from 3 to 6 ft. above bedrock. The gold recovered is coarse, varying from wheat grains to nuggets in size. The fineness of the gold is 914 to 924. The largest nugget recovered had a value of $300. It is reported that gravel on the bedrock will carry $5 to $6 per cu. yd. The bedrock is limestone. There are large boulders, made up of granite, quartzite, and schist.

Development consists of two shafts sunk to bedrock through gravel wash. The west shaft is situated 250 ft. from the west end line, on the north rim of the canyon, and has been sunk on an inclination of 45° to a depth of 100 ft. to bedrock, with a drift on the bedrock on the 100-ft. level, 250 ft. west and 450 ft. east. About 570 ft. east of this shaft, the main working shaft has been sunk on an inclination of 65° to bedrock, to a depth of 96 ft. This shaft is located in the center of the channel. On the 96-ft. level there is a drift 130 ft. west and 150 ft. east, also 100 ft. of crosscuts to the rim of the channel. Equipment consists of a 3 hp. Fairbanks-Morse gas engine hoist, bucket with a capacity of 300 lb., gravel hoisted to ore pocket from which it passes over a 2 in. grizzly, oversize to waste dump, minus 2 in. size to trommel where it is screened to ½ in., which goes to a Stebbins Dry Concentrator with a

capacity of $1\frac{1}{2}$ yd. per hour. The gravel mined amounts to 4 cu. yd. per 8-hr. shift. Two men are employed.

Davis Group of Placer Claims. It comprises 4 claims, situated in the west end of Marble Canyon, about one mile west of Waucoba-Saline Valley Road, 22 miles southeast of Big Pine; elevation, 6200 ft.; owner, Mrs. J. E. Davis, of Big Pine.

The course of the channel is east and west; width, 150 to 200 ft.; length along the channel, 3000 ft. The bedrock is schist and slate. There are large boulders of granite, quartzite and schist.

Development consists of shaft, 150 ft., sunk through gravel. So

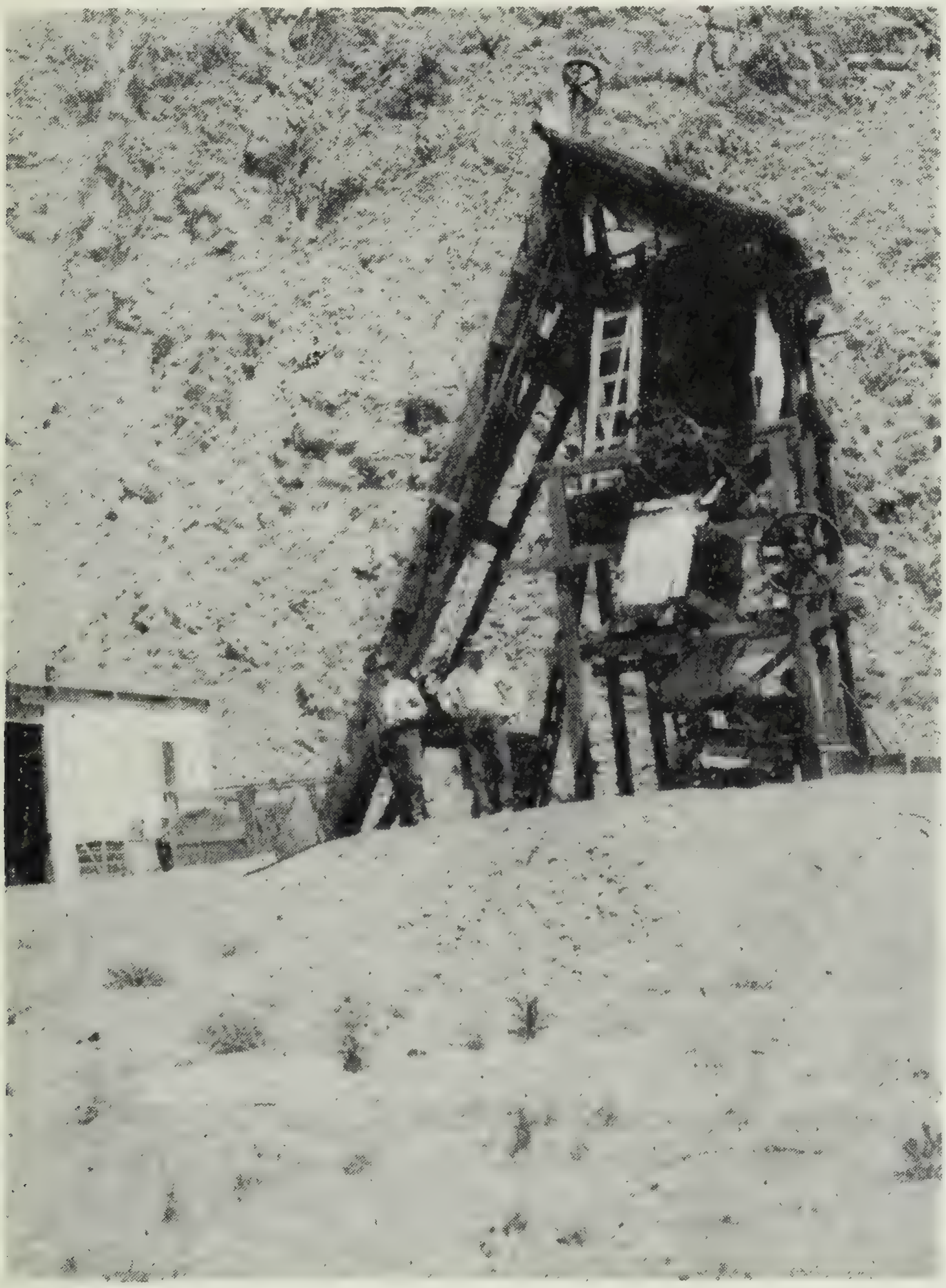


Photo. 5. Bedell Shaft. Marble Canyon Gold Placers, Marble Canyon, Inyo County.

far, workings have not encountered bedrock. Some fine gold has been recovered. Mine equipment consists of gasoline hoist and cars. Two men are employed.

Hallelujah No. 3 Placer Mine. It comprises one claim, adjoining the Bedell Group on the east, located in Marble Canyon, 23 miles southeast of Big Pine; elevation, 5900 ft.; owners, Dr. Vaughn, of San Pedro, and Harry Mornway, of Big Pine.

The course of the channel is east and west, with 1400 ft of it on this claim. Width of channel is 60 ft. The pay gravel is on bedrock to 3 ft. above. The bedrock is limestone. Gold recovered is coarse, running from wheat grains to nugget size. The largest nugget so far recovered had a value of $22, with a fineness of 920.

Development consists of incline shaft sunk to a depth of 103 ft., with a drift west on pay gravel 150 ft. and east 150 ft., and a crosscut north across the channel to the north rim, a distance of 60 ft. Gravel, hoisted and screened, is run over a dry washer. Two men are employed.

Iron Nugget Placer Mine. It comprises 2 claims, located in Marble Canyon where Waucoba-Saline Valley Road crosses the canyon, 23 miles southeast of Big Pine; elevation, 6000 ft.; owners, F. B. Krater, W. H. Van Norman and C. H. Van Norman, of Los Angeles; under lease to Glen P. Kelley, of Big Pine.

The course of the channel is east and west, 2000 ft. along the channel; width of channel, 75 ft. The pay gravel is 6 ft. thick; bedrock, limestone. Large boulders are encountered in the channel. The gravel is made up of quartz, quartzite, schist and granite rocks. The gold found on the bedrock is coarse, running from wheat grains to nugget size. The largest nugget recovered is said to have had a value of $29. The fineness of the gold is 924. A number of nuggets recovered ran from $12 to $21. The pay gravel is stated to have a value of $6 per cu. yd.

Development consists of a shaft sunk on an inclination of 65° to a depth of 146 ft. where it encountered the north rim; from bottom of shaft, incline winze 125 ft. to center of channel on 25° slope. The channel has been drifted 550 ft. The gravel is hoisted in a bucket by a gasoline-driven hoist to a bin, then passed over a 2-in. grizzly, oversize to waste dump and minus 2 in. size material to a hopper, from the hopper to a bucket elevator to a trommel screen, where it is screened to $\frac{1}{2}$ in. size, then to a Lewis dry washer. Two men are employed.

Krater-Van Norman Group of Placer Claims. These claims are located in Marble Canyon, 3 miles east of Hallelujah No. 3 Claim, 26 miles southeast of Big Pine; elevation, 5600 ft.; owners, F. B. Krater and W. H. Van Norman, of Los Angeles.

Development consists of incline shaft, 115 ft. deep to bedrock, with a drift north, 150 ft. It is reported that no pay gravel was encountered. Idle.

Lewis Group of Placer Mines. The property comprises 4 placer claims, located in Marble Canyon, in T. 10 S., R. 37 E., M. D. M., 23 miles southeast of Big Pine; elevation, 6000 ft.; owner, J. C. Lewis, of Big Pine.

This mine was one of the first producing placer mines of the Marble Canyon District. The general course of the channel is east and west, following the rims of the canyon. The length is 4800 ft. on the channel. The pay gravel has an average width of 40 ft. The height of the pay gravel above bedrock is 6 ft., reported to average $5 per cu. yd. The gold recovered is coarse, wheat grains up to nugget size. Nuggets recovered vary from $3 to $20 in value. The bedrock is limestone. The gravel is made up of quartzite, granite, quartz, and schists, with some large boulders.

Development consists of two shafts each 115 ft. to bedrock, with 500 ft. of drifts. Mine run of gravel is hoisted in buckets, then passed over a 2 in. grizzly, minus 2 in. size to trommel where it is screened to $\frac{1}{2}$-in size, which goes to a Lewis dry washer for the recovery of gold.

Marigold Mine. (See Golden Rod Mine.)

Mazourka Canyon Placers. These placers are situated on the west slope of the Inyo Range of mountains, in T. 12 S., R. 35 E., 10 miles northeast of Independence; elevation, 5000 to 7000 ft. The gold is found in a wash of Mazourka Canyon extending in a northerly direction from Barrel Springs to Santa Anita Spring. These placers were first discovered in 1894 and worked until 1906 with dry placer equipment. In 1935, *Nodak Mining Company;* G. M. Booker, president; J. H. Blain, secretary, Los Angeles, secured a lease on a group of placer claims along Pops Gulch, one mile east of Santa Anita Spring. The general course of the channel is east and west, is 500 ft. in width and from 5 to 20 ft. deep. The bedrock is lime shale and granite. The gold occurs in glacial drift material made up of lime shale, and angular wash material with occasional pieces of quartz with gold. Nuggets recovered are fairly coarse, ranging in value from 50 cents to $10; fineness, 940 It is stated that gravel being treated will carry 20 cents to $2 per cu. yd. Gravel is loaded into 5-ton truck with P & H gas-driven shovel, with $\frac{3}{4}$ bucket, then hauled one mile to washing plant at Santa Anita Spring. The gravel is dumped into a bin having a capacity of 50 cu. yd.; material from bins goes to 16-in. belt conveyor, which conveys gravel to hopper on 6-unit Huelsdonk gold concentrator, driven by 30-h.p. caterpillar gas engine. From hopper 6-mesh material goes to concentrator, oversize material to waste dump. Machine has a capacity of 25 yd. per hour. Water supply is secured from well 30 ft. deep, located at Santa Rita Spring. Well has a capacity of 34,000 gallons. Water pumped from well through 4-in. pipe line 600 ft. in length to 4 storage tanks.

Four men employed.

Bibl: State Mineralogist's Reports XII, p. 139; XIII, p. 182.

Merry Christmas (see St. George).

Moffatt Mine. It comprises 7 claims, situated in Buttermilk Mining District, 13 miles southwest of Bishop. Elevation 7000 ft. Owners, J. W. Brown, R. M. Wells, of Bishop, California.

A vein of iron-stained quartz occurs in granite, strike NW.-SE., dip 40° SW., width 3 ft. No. 1 shaft is sunk on vein to a depth of 50 ft. About 200 ft. northwest of this shaft is No. 2 shaft, which is sunk on the vein to a depth of 50 ft. Mine equipment consists of 6-h.p. gas engine hoist. Ore is treated in a 5-stamp mill, with amalgamation plates and Wilfley concentrator.

Two men employed.

Mohawk Mine comprising 12 claims is in the Argus Mining District, on the east slope of the Argus Mountains, 7 miles northwest of Trona. Elevation about 2500 ft. Owner, J. C. Boyles, Trona, California. Under lease to L. E. Netherton, of Red Mountain, California.

Here in the granitic country rock there occurs an E.-W. vein which dips approximately 80° to the north. The width, between walls varies from about 3 to 14 ft. The vein-filling consists of quartz and altered country rock with many encrustations of calcite. The valuable mineral is a fine, free gold, no sulphides.

Development work consists of a shaft sunk on a 70° inclination 168 ft. At 60 ft. the shaft connects with a tunnel which was driven west about 300 ft. The shaft is 200 ft. from the portal of this tunnel. On 110-ft. level a drift about 65 ft. east connects with an old stope, drift west about 300 ft., the last 250 ft. of which is reported to be an ore-shoot. The average width is about 5 ft. At the 160-ft. level, cross-cut 30 ft. south to vein, drift west 400 ft. At 60 ft. from shaft struck ore shoot 160 ft. long, 3 to 14 ft. wide. The last 20 ft. of this drift is reported to be in good ore. At 100 ft. from the cross-cut there is a raise to the 110 ft. level. There is also a drift east 335 ft. of which the east 200 ft. is reported to be ore for a width of 7 ft. Average values are reported to be $8 per ton.

Mill consists of jaw crusher, elevator to screen, rolls to 4 leaching tanks. A $\frac{5}{16}$ in. product goes to the tanks. Capacity 30 tons per day. Water is pumped from Homeward Canyon a distance of 6500 ft. Idle at time of visit.

Mountain Springs Canyon Mine (*Bonanza*). It comprises 20 claims, known as the Convention Group, situated in the Argus Mining District, in Mountain Springs Canyon, in Sec. 7, 8, 9, 17 and 18, T. 23 S., R. 41 E., 20 miles northeast of Brown, a station on Owens Valley Branch of the Southern Pacific Railroad; elevation, 4280 ft.; owner, Mountain Springs Canyon Mining Company; I. C. Lewis, president; J. Torrence, secretary; Ralph Blewitt, vice president and general manager, 907 Van Nuys Building, Los Angeles, California.

A series of parallel veins occur in the granite, along fissures and fault zones and on contacts of intrusive dikes of diorite porphyry and andesite porphyry. All the veins on the property contain quartz with variable amounts of pyrite and chalcopyrite. Seven parallel veins have been developed on the property, with widths varying from 12 in. to 4 ft. The veins strike N. 30° E., to N. 45° E., and dip 30° to 40° NW. The principal development work has been confined to the Convention No. 2 Claim, where a shaft has been sunk on the vein to a depth of 185 ft. On the 138-ft. level, drift SW. 338 ft. and NE. 70 ft. At 75 ft. in elevation and SW. of shaft No. 2 is vein No. 1, on which there is an incline shaft 70 ft. deep, with a drift SW. 130 ft. on the 60-ft. level, and NE. 100 ft.; average width of the vein being 1 ft. Ore values on the two veins so far developed are reported to carry from $9 to $20 in gold and silver per ton.

Mine equipment: 15 hp. Fairbanks-Morse gas engine hoist; 8 by 8 in. Curtis compressor driven by a 30 hp. Climax gas engine; ($5\frac{1}{2}$ by $3\frac{1}{2}$ by 5 in.) Fairbanks-Morse station pump; ($4\frac{1}{2}$ by 3 by 4 in.) Fairbanks-Morse sinking pump.

Mill equipment: 6 by 8 Blake crusher; 4 by 4 ft. Federal ball mill; Dorr Duplex classifier; Wilfley table.

Idle.

Bibl.: State Mineralogist's Reports XII, p. 136; XIII, p. 180.

Mountain Springs Canyon Gold Placers. It comprises 100 acres situated in Water Canyon, 30 miles northeast of Brown; owner, Curtis W. Shields, Jr., Beverly Hills, California.

Gravel is reported to carry 50 cents to $1 a cu. yd.; developed by shafts 6 to 8 ft. to bedrock.

Mountain View Mine. It is situated in the Beveridge Mining District, adjoining the Keynote Mine on the north, on the east slope of the Inyo Range of mountains, 10 miles northeast of Owenyo, a station on the California and Nevada Railroad; elevation, 8000 ft.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 82; XXII, p. 471.

New Discovery and Gem Mines, comprising 5 claims, is situated in Jail Canyon, on the west slope of the Panamint Mountains, 14 miles north of Ballarat and 3 miles up the canyon from the valley floor. Elevation 3700 ft. Owner, *Gem Mines Incorporated;* E. S. Saint Clair, of Bakersfield, president.

Two veins occur in the granitic country rock near its contact with the schist. Strike N. 25° E., dip about 65° W. The principal vein on which all of the work has been done varies in width from about 2 to 12 ft. The vein-filling is quartz; mineralization consists of pyrite, pyrrhotite, a little chalcopyrite, bornite, galena and zincblende. The gold is associated with the sulphide minerals.

Development consists of a tunnel driven north 260 ft. and a vertical shaft 220 ft. deep. Levels have been driven at 75, 125 and 200 ft. horizons. An ore shoot about 50 ft. long and from 2 to 12 ft. wide was developed and stoped on the 75 and 125 ft. levels. On the 200-foot level a crosscut has been driven 50 ft. into the hanging wall. At a few feet from the shaft the crosscut passed through a stringer zone and at 42 ft. it passed through 11 ft. of talc. The stringer zone probably is the vein. No drifting has been done on this level.

Mine equipment consists of hoist, 6 by 5½ in. compressor driven by gas engine.

The 25-ton mill consists of 9 by 12 jaw crusher, elevator bin, 4 by 5 ft., ball mill, simplex Dorr type classifier, Groch, 4-cell flotation unit and table. Mill power is furnished by 50-hp. diesel engines. Five men working.

Bibl.: State Mineralogist's Report XXVIII, pp. 364-366.

North Star Mine. It comprises 7 claims, situated on the east slope of the Inyo Range of Mountains, 6 miles northwest of Cerro Gordo Mine, and about 45 miles by road east of Keeler; elevation, 5000 ft.; owners, D. E. Boelter, Earnest Mound, and Elhan Hillegast, of Los Angeles. A number of parallel quartz veins occur in granite; strike N. and S., dip 80° W.; widths vary from 2 to 6 ft. Vein quartz is mineralized with galena, pyrite, and chalcopyrite, carrying values in gold and silver. Development consists of shallow shafts and open cuts on different vein outcrops. Four men are employed on development.

O. B. J. Mine (Tyler Mine), with which is consolidated the Thurman and Aster Mines, comprising 14 claims, is on the south side of Tuber Canyon, on the west slope of the Panamint Mountains, some

15 miles north of Ballarat; elevation at principal workings, 3450 ft.; owners, C. W. Tyler, Trona, California, and Mrs. Reed, Santa Barbara, California; under lease and bond to *L & H Corporation;* Wilbur S. Ganse, 629 Subway Terminal Bldg., Los Angeles, California.

These properties were fully described in our Report XXVIII, pp. 371-372, under the name of *Panamint Mines Company.*

The present lessee's operations have been largely confined to sampling and mapping.

Two men are employed on this work.

Bibl.: State Mineralogist's Reports XV, p. 74; XXII, p. 465; XXVIII, pp. 371-372.

Olympic Mine. It comprises 3 claims situated in the Argus Mining District, on the west slope of Argus Range of mountains, 35 miles northeast of Brown, a station on Owens Valley Branch of Southern Pacific Railroad; elevation, 5500 ft.; owner, Joe Conner, Los Angeles, California.

A quartz vein 4 ft. in width occurs in quartz diorite; strike NE.-SW., dip 30° SE. A tunnel 200 ft. in length has been driven on the vein.

Idle.

Orion Mine. It comprises 5 claims situated in the Coso District, 2 miles southeast of Coso; owned by Walter Ross and E. W. Robinson. Developed by an incline shaft on the vein to depth 53 ft.; on 50 ft. level, drift east 15 ft. A 4-inch stringer in the footwall yielded two tons in 1937 assaying 2.34 oz. in gold and 4.16 oz. in silver.

A tunnel was run 185 ft. north on a second vein 14 in. wide; strike E.-W.; vertical dip. averages about $6 in gold. Equipment consists of a Star gas engine hoist.

Two men are employed.

Oro Grande Placer Mine. It comprises one claim owned by Sam S. Clark, situated 1½ miles southwest of Coso.

Clark is operating a small, dry placer machine consisting of a ½-in. screen, bellows and riffles and an 8 ft. conveyor belt stacker. The bellows and conveyor are operated by a Briggs and Stratton 4-cycle gasoline motor.

Polita Mine, comprising 4 claims, one patented, is in Polita Canyon, on the west slope of the White Mountains, 8 miles east of Bishop; elevation, 5500 ft.; owners, C. H. Olds and A. E. Beauregard, of Bishop, California; leased to H. A. Van Loon, of Bishop.

This is an old property, most of the development work having been done many years ago. The quartz vein, having an E.-W. strike, dip 35° N., occurs in limestone. It varies from a few inches to 2 ft. in width. The mineralization consists of pyrite and in the oxidized portions, free gold and limonite.

Development consists of a tunnel some 400 ft. long. At about 200 ft. from the portal of this tunnel, a shaft has been sunk 600 ft. on a 35° inclination. Levels now open and partially accessible are: 200 level; drift E. 400 ft., with a stope 40 ft. long by about 25 ft. high; 250 level, drift W. 250 ft., first 100 ft. stoped and filled; 350 level,

drift E. 150 ft., stoped, with a drift west which has been stoped and filled; 400 level, drift E. 60 ft., stoped and filled; 530 level, drift W. 100 ft., stope 40 ft. long by 30 ft. high; 600 level, drift W. 50 ft., stoped, drift E. 50 ft. The east drift is now being driven. The vein here is about 8 in. wide and carries about $35 per ton in gold.

The mill is in the canyon, about one mile south of the mine and approximately 1000 ft. lower. It consists of 7 in. by 11 in. jaw crusher, to $2\frac{1}{2}$ by 3 ft. ball mill, to 40 mesh revolving screen; screenings to plates, plate tails and over size from screen pumped to drag classifier; overflow to 2 Kraut flotation cells, sands to ball mill. On the sulphide ores an extraction of 96% is said to be made. The plant has a capacity of 12 tons per day at 100 mesh. Some 4000 tons have been treated by the present operation.

Three men are employed.

Bibl.: State Mineralogist's Reports XII, p. 139; XIII, p. 183; U. S. G. S. Prof. Paper 110, p. 120.

Radcliff Mine, consisting of 10 patented claims and a millsite, is situated on the south side of Pleasant Canyon, on the west slope of the Panamint Mountains, about 6 miles east of Ballarat; elevations on the property range from 4000 to 7000 ft.; owner, W. D. Clair on the property; post office address, Trona, California.

Since our last report on this property (1932), Mr. Clair has continued to mill the old tailings left by former operators.

Bibl.: State Mineralogist's Reports XXII, p. 472; XXVIII, pp. 373, 376.

Rainbow Group of Mines. This group comprises 25 claims, situated in Secs. 12, 21, 22, T. 22 N., R. 7 E., $3\frac{1}{2}$ miles east of Shoshone, in Resting Springs Mining District; owner, A. W. Plummer, 2062 Glencoe Way, Hollywood, California.

Series of parallel veins which strike NW.-SE., occur in andesite. Vein widths are from 15 to 25 ft. Large low-grade deposit with values reported to range from $1.25 to $2.50 per ton in gold. Development consists of a number of shallow shafts and open cuts.

Two men are employed on development.

Red Mexican Mine. It comprises one claim and a fraction in the Coso Mining District, 3 miles south of Cold Springs; owned by C. M. Turner, of Las Vegas, Nevada; R. E. Lafink and M. D. Early, of Lancaster, California; under lease and bond to Glenn Hart, Ed. Cardwell, George Pyle, of Lancaster, California.

Developed by a 150-ft. vertical shaft and a tunnel driven 370 ft. northeast on the vein connecting with shaft on the 100-ft. level. On the 150-ft. level a drift has been driven 25 ft. southwest on the vein. The vein is from 6 in. to 18 in. wide and dips 20° W. Eight tons shipped from the tunnel on the 100 ft. level netted $152.

Equipment consists of a 240 cu. ft. Worthington portable compressor. Two men employed.

Reward Mine. (See *Brown Monster.*)

Rex Montis Mine consisting of 4 patented claims is on the north slope of Kearsarge Mountain, about 9 miles northwest of Independence;

elevation 12,000 ft.; owner, Howard Mears, Independence, Calif., and N. E. Conklin Co., San Francisco, Calif.

This is an old property which, from best information obtainable, was last worked from 1875 to 1883. In 1877 Rex Montis Mining Co. produced 12,333 oz. of gold and silver bullion. In 1935 an attempt was made to cut the ice out of the tunnels but weather conditions prevented completion of this work.

It is reported that three quartz veins occur between granite walls. The average width of veins is said to be 3½ ft. The vein quartz carries both native gold and silver. The ore is reputed to have been high grade.

The property was developed by three tunnels, supposedly driven on separate veins. The upper and lower tunnels at 12,000 and 10,500 ft. elevations, respectively, are partially caved and filled with ice. In the summer of 1935, ice was cut from the middle tunnel for a distance of 260 ft. This work exposed stopes on three ore-shoots. These stopes are 80, 20 and 55 ft. long and have an average width of 3½ ft. At an elevation of about 10,500 ft., a shaft was sunk on a wide vein to an unknown depth. Some stoping was done in the shaft as the stopes were holed through to surface. These workings are now caved.

Idle.

Ruiz Mine, comprising three claims is in the Argus Mountains, 5 miles north of Darwin. Elevation about 5200 ft. Owners: R. C. and R. E. Ruiz of Lone Pine, California.

The vein which strikes N. 35° W. and dips 50° to 35° S. W. occurs in the quartz monzonite country rock. It is a fault fissure filled with quartz. It varies in width from 2 to 5 ft. The portion next to the hanging wall, from 1 to 1½ ft. being highly oxidized, carrying values in free gold. The remainder, adjacent to the foot wall, is unstained quartz showing considerable sulphides.

Development consists of a 65-foot shaft sunk on the vein. Assays as high as 14 ozs. in gold have been reported. A shipment of 1½ tons to the Tropico mill is said to have returned $100.

Idle.

Ruth Mine (Graham-Jones). It comprises 13 claims, known as Ruth, Ruth No. 1, No. 2, No. 3; Island, Empire, No. 1, No. 2 and No. 3; Crown, Crown No. 2; Red Bluff, West Extension, and Larry Jean, situated in Homeward Canyon, in the Argus Range of mountains, in South Park Mining District, 12 miles north of Trona; elevation 4000 ft.; owners, Graham Estate, Porterville, Calif.; F. L. Austin, Trona, Calif.; H. R. Evans, Kernville, Calif.; under lease and bond to *Burton Bros. Inc.*, Tropico, Calif.; George Wyman and N. E. Sweetzer, Mojave, Calif.

Ore occurs along a fault fissure in quartz-monzonite, strike N. 75° E., dip 70° S.; width 6 ft. to 40 ft. The gold occurs in a very fine state in iron-stained porphyry, associated with pyrite.

Development consists of tunnel driven N. 75° E., 700 ft. on which level an ore shoot 100 ft. in length, with an average width of 9 ft. was developed. At 700 ft. from portal, a 2-compartment winze was sunk to a depth of 100 ft. with a drift west 150 ft. and 100 ft. east. The ore-shoot developed on this level is 200 ft. in length, with an average width of 10 ft. with a reported average value of $14 per ton in gold. There is a glory hole 40 ft. wide and 200 ft. in length, 150 ft. in elevation

above tunnel level. On glory hole level, a tunnel has been driven east 400 ft. Former operators mined and milled 10,000 tons of ore from the glory hole. Estimated tonnage of ore developed from the glory hole level is stated to be 30,000 tons of ore with an average value of $6 per ton in gold. Between the tunnel level and the glory hole level it is estimated that there is developed 10,000 tons of ore with an average value of $6 per ton. Between the tunnel level and the winze level it is stated that there is developed 10,000 tons of ore with an average value of $15 per ton in gold. The total estimated tonnage of ore is said to be 50,000 tons.

PHOTO. 6. View of Upper and Lower Tunnels Ruth Mine, Argus Range of Mountains, Inyo County.

Water for mining and milling operations is secured from springs one mile west of the mine and flows by gravity through a 2-in. pipe-line to a storage tank having a capacity of 20,000 gallons.

Mine equipment consists of a 75 hp. 2-cylinder Fairbanks-Morse diesel engine which drives 310-cu. ft. Ingersoll-Rand compressor; 15 hp. single drum air hoist; blacksmith shop; air drills, and mine cars.

Mill: Ore trammed in one-ton ore cars to coarse ore bin having a capacity of 35 tons; from the coarse ore bin to a 12-in. by 16-in. Blake crusher, crushed to 1½-in. size to 16-in. belt conveyor over Dings mag-

netic pulley to Symons cone crusher, crushed to ¼-in. material from Cone crusher to 16-in. belt conveyor to revolving screen, the minus ¼-in. material to fine ore bin, capacity 75 tons, oversize material from revolving screen returned to Cone crusher. Mill driven by 80-h.p. Atlas

PHOTO. 7. Crushing Plant—Capacity 70 tons. Ruth Mine, Argus Range of Mountains, Inyo County.

Imperial Diesel engine. From fine ore bin the ore is hauled by truck to eight 6 by 15 ft. steel tanks for leaching; one 5 by 25 ft. solution tank. Solution from tanks to sand filter, then to two 4-compartment zinc boxes. In leaching operations 8 lb. of lime to a ton of ore treated is used, with 2½ lb. of sodium cyanide. Average value of ore treated is said to be $7 per ton in gold, with a loss of 70 cents per ton in tailings. Expect to increase the value of ore to $12 per ton when stoping operations are started on winze level.

Ten men are employed. Present production stated to be $5,000 per month.

St. George Mine (Merry Christmas). This property comprises 12 claims situated on the east slope of the Argus Range of mountains, on ridge northwest of Snow Canyon, in the Modoc Mining District, 34 miles north of Trona, California; elevation 4500 to 5500 ft.; owner, J. C. Cress Estate and Marie E. Strezer, of Los Angeles; under lease and bond to Charles F. Hamilton, 1541 So. St. Andrews Place, Los Angeles, California.

From 1895 to 1896 the property was operated by the *Argus Gold Mining Company,* which company installed a 5-stamp mill. In 1913 and 1914, the mine was operated by the *Snow Canyon Mining and Milling Company,* Dallas, Texas. This company installed two aerial tram lines from mines to the mill. In recent years the property was oper-

ated off and on by John C. Cress. Two systems of veins occur in the granite; one strikes N. 50° W., dip 70° to 75° S. Widths vary from 2 ft. to 4 ft. The other system strikes E.-W.; dip 70° S. The vein quartz shows free gold associated with pyrite, chalcopyrite and arsenopyrite. The principal development work has been on the St. George and St. Patrick claims, also on the California group of claims. At an elevation of 5500 ft. on the St. George claims, a tunnel has been driven N. 20° E., 282 ft. to the vein, then a drift has been run on the vein N. 50° W. 500 ft. About 45 ft. south of these workings, there is a tunnel driven along a fault fissure in the granite, N. 70° E. 650 ft. and then a drift N. 40° W. 200 ft. (see Fig. 7). The vein developed in this drift has a width of 3 ft. The St. George shaft has been sunk on the vein to a depth of 200 ft. where it connects with a raise from the north tunnel level, at a point 447 ft. northwest of the crosscut tunnel (see Fig. 6). About 500 ft. northwest of the St. George shaft, there is a tunnel 200 ft. in length on the same vein. Ore mined from levels of the St. George shaft was dropped through the raise to the tunnel level and trammed in cars on the surface for 1000 ft. to the ore bin, then by aerial tram to the mill. The ore mined from the St. George vein is reported to carry from $15 to $25 per ton in gold. On the California claim there is a tunnel driven on the vein N. 50° W. 180 ft.; at 100 ft.

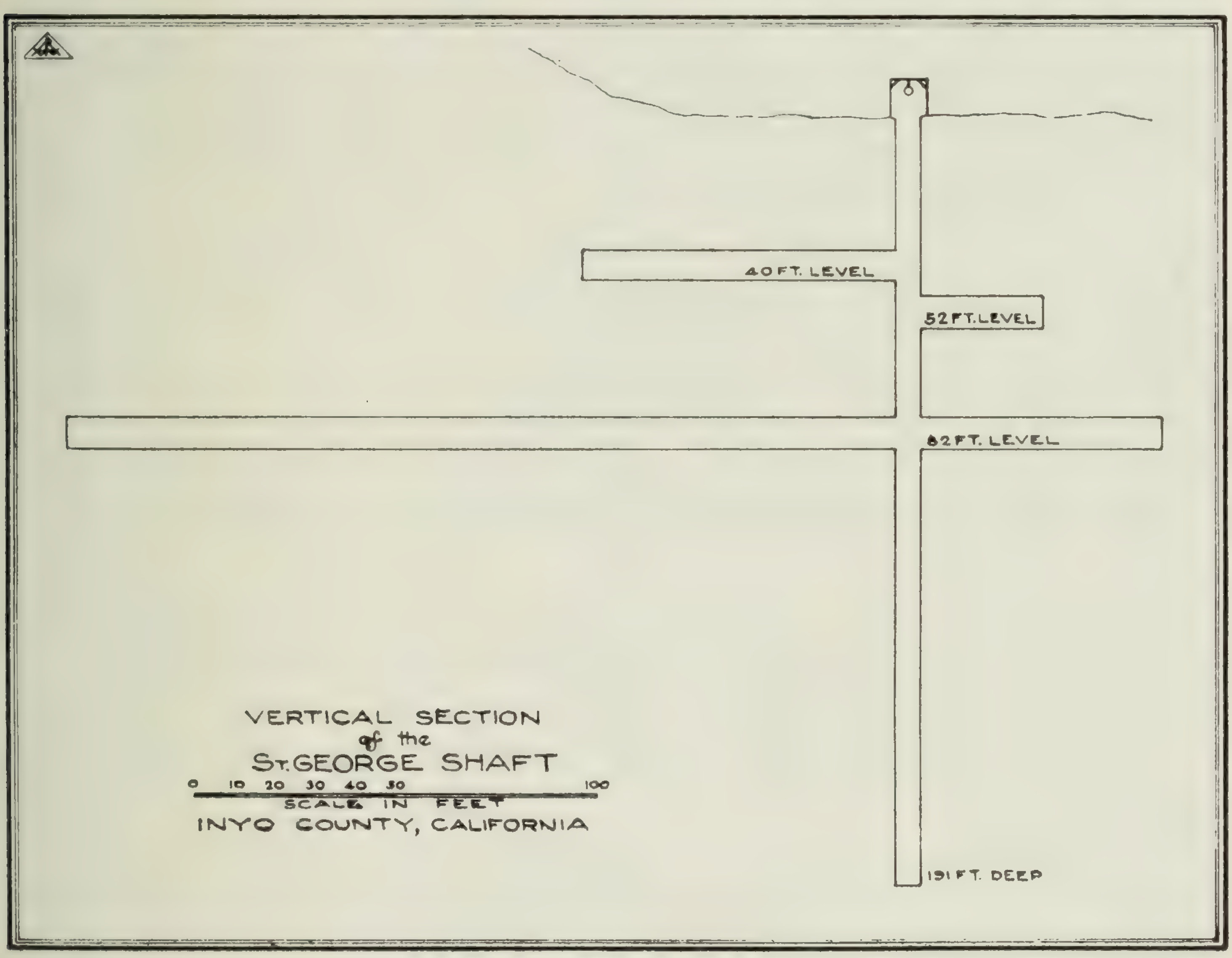


FIG. 6.

from the portal there is a winze 50 ft. deep. The vein strikes N. 50° W., dip 70° SW.; width 4 in. to 12 in., reported to carry high values in gold. This claim is under lease to Jake Hodge and associates who are driving the tunnel on the vein. Mill consists of 25-ton coarse-ore bin,

6 in. by 8 in. Blake crusher, Challenge ore feeder, five 1000-lb. stamps amalgation plates and Diester concentrator. Mill driven by 20-h.p.

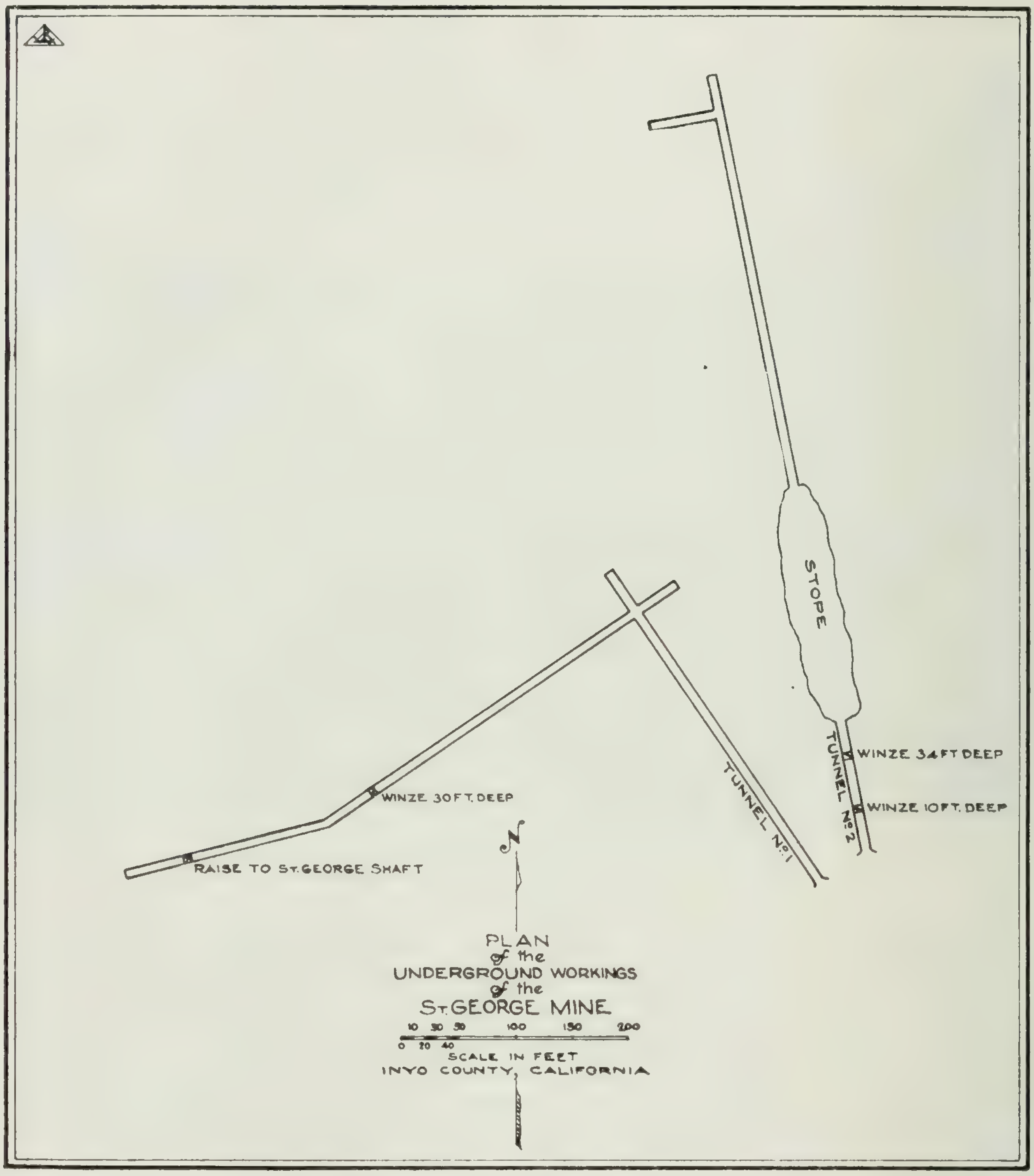


FIG. 7.

Foos gas engine. It is estimated that there are 700 tons of tailings below mill stated to have an average value of $8 per ton in gold.

Two men are employed.

Bibl.: State Mineralogist's Reports XII, pp. 136, 140; XIII, p. 179; XV, p. 82.

Skidoo Mine (*Silver Bell*). It comprises 12 claims, situated in the Wildrose Mining District, on the west slope of the Panamint Range of mountains, 65 miles north of Trona; elevation, 6500 ft.; owner, Judge W. Gray, Las Vegas, Nevada; under lease to *Journigan Mining & Milling Company;* Roy Journigan, president and manager, Trona, California.

There are two systems of quartz veins that occur in quartz-monzonite. The main vein system strikes northwest and dips from 30° to 40° SW. The other system trends east and dips 60° N. The

veins average from 18 in. to 2 ft. in width, with a maximum width of 4 ft. The ore is free-milling and values range from $15 to $20 per ton in gold. The outcrops of eight veins have been mined from tunnels.

Development consists of incline shaft 300 ft. deep, sunk on the east vein system, and a vertical shaft 300 ft. deep, on the main vein system, with over one mile of tunnels and drifts.

The property was operated by *Gray and Worcester Mining Co.* from 1935 to 1937. The ore mined was hauled by truck to Journigan Mining & Milling Company for treatment. In January, 1937, Roy Journigan secured a lease on the property and at present 5 men are employed getting out ore from old stopes on the property, also hauling dump material to Journigan's mill for treatment.

The mill is situated in Emigrant Canyon, being an amalgamation and cyanide plant with a capacity of 25 tons per day. Twenty-five-ton ore bin, 6 in. by 8 in. Blake crusher, 25-ton fine ore bin, to a 3 ft. by 4 ft. Straub cone-type of ball-mill, ground in cyanide solution to 20-mesh; pulp flows over 4 by 8 ft. amalgamation plates, then to seven 14 ft. by 5 ft. cyanide tanks, solution from tanks to 4-compartment zinc boxes. Mill operated by 15 h.p. Fairbanks-Morse gas engine. This mill also operated as a custom mill for ore in the district. Four men are employed.

Bibl.: State Mineralogist's Report XV, pp. 83, 84; XXII, p. 473.

Southern Homestead Mine, comprising 10 claims is on the west slope of the Panamint Mountains, 10 miles south of Ballarat; elevation about 3500 ft.; owner, Harry E. Briggs, Trona, California, with whom there is associated James E. Babcock, Rives-Strong Bldg., Los Angeles, California.

Here in the quartzite, are found three (possibly there are more) altered diorite dikes. The strike is NE., dip about 10° to 15° SE. These dikes are mineralized with auriferous pyrite, some pyrrhotite and a little very fine, free gold. They vary in thickness from 2 to 15 ft. as now exposed. One of these dikes has been traced by a series of trenches and short tunnels a distance of about 400 ft. along the west slope of the mountain and about 300 ft. in the south side of the canyon. Samples taken show values from $2 to $16 per ton in gold, with an average value of about $10.

Idle at the time of visit.

Star of the West Mine. The property comprises 7 patented claims, situated on the ridge north of Wilson Canyon, 20 miles northeast of Brown, a station on the Southern Pacific Railroad; elevation, 5000 ft.; owner, W. D. Alexander, 320 E. Jefferson St., Los Angeles, California.

A flat-dipping vein of quartz occurs in granite, strike NW.-SE., dip 20° SW.; width 3 ft.; developed by a number of tunnels 50 ft. to 100 ft. in length. The mine was operated in 1916 and the ore mined was transported over an aerial tram to a mill in Wilson Canyon. Southeast of these workings is a diorite dike intruding the granite, strike NW.-SE., dip 75° NE. On the northeast side of this dike there is a vein of quartz 18 in. wide. A shaft has been sunk on this vein to a depth of 20 ft.

Idle.

Stockwell Mine, consisting of 6 unpatented claims, and 10-acre millsite, is on the west slope of the Slate Mountains, 10 miles NE. of Trona; elevation, 3000 ft.; owner, Stockwell Gold Mining Company; E. E. Teagle, president; V. E. Stockwell, secretary, Los Angeles; under lease and bond to *Century Mining Company;* Julius E. Linde, president; Roy E. Orvedahl, secretary; office, Trona, California.

The property was discovered in about 1897, and acquired by B. P. Greenleaf and V. E. Stockwell early in the twentieth century. They organized the company in 1918, after doing about half of the development work described below. Present company started operations September, 1937.

The vein in the granitic country rock strikes N. 20° W. and dips about 60° NE. It varies in width from 3 ft. to 30 ft. between walls, maximum width of ore probably being about 12 ft. Vein filling consists of talc, crushed quartz and altered wall rock. Mineralization consists of iron pyrite with a little chalcopyrite.

Development consists of a cross-cut driven east 136 ft. to the vein; drift N. 240 ft. to a 200-ft. vertical shaft, from surface which it intersects at the 50 ft. level. On the 200-ft. level of this shaft, a cross-cut has been driven 32 ft. to the foot wall of the vein but has not gone through the vein. On the tunnel level a drift has been driven south 574 ft. from the cross-cut. At 510 ft. from the cross-cut, the drift intersects an incline shaft from surface. This shaft is sunk on a 60° inclination for 260 ft. The tunnel level is 120 ft. below the surface. In the tunnel an ore shoot begins some 50 ft. south of this shaft and appears to extend north some 170 ft., varying in width from 3 ft. to 12 ft. It is approximately 200 ft. north from this shoot to another similar one, which is reported to be 200 ft. long.

On the 170-ft. level of incline shaft, drift north about 60 ft. to hole raise from 210 ft. level. On 210-ft. level, drift north about 280 ft. south 30 ft. The north drift picked up the south shoot showing some sulphides. On 260-ft. level, drift north 90 ft. Vein here is vertical, about 12 ft. wide. At 127 ft. south of crosscut, a winze has been sunk to a vertical depth of 100 ft., developing 6 ft. of sulphide ore. The vein material is quartz, mineralized with pyrite and chalcopyrite. About 1000 ft. north of these workings and in the next canyon a vertical shaft has been sunk 150 ft. (inaccessible at time of visit). Reported that on the 150 level, a drift was driven northwest 140 ft. and crosscut from the face northeast, with a drift from the crosscut southeast, a total of 400 ft. on this level. Several short tunnels and open-cuts have been made in this canyon. These workings show a vein on each side of a monzonite dike which is about 100 ft. wide. Some 750 ft. west of this canyon several tunnels have been driven, one of which is about 700 ft. long. This work was done on a vein, strike N. 70° W., which appears to form a junction with the veins mentioned above, in the canyon.

The present company during the latter part of 1937, shipped 400 tons of ore to the Selby Smelting Co. stated to have an average value of $25 per ton in gold and 2% in copper. At the camp and millsite which is 3 miles west of the mine at an elevation of 1900 ft. there is a well 270 ft. deep, which supplies water for the camp and for the mine and mill.

Mine equipment consists of Worthing portable compressor with a capacity of 260 cu. ft. air drills and Ingersoll-Rand tugger hoist.

The company is planning to install a 50-ton flotation plant for treatment of the ore.

Two men are employed.

Sunrise View Mines. The property comprises two groups of claims known as Sunrise View group of 14 claims, and Lucky Strike group of 10 claims, located in the Alabama Hills, 3½ miles north of Lone Pine; owners, A. C. Zell, Lone Pine; R. A. Yahnka and Lillian Yahnka, of Huntington Park, Calif.

The principal mineralization occurs along a shear zone in lime-silicate rock in country rock of granite. The shear zone is about 200 ft. in width, with granite hanging and footwall. The strike of the shear zone is S. 80° W., with a dip 70° to 80° N. Quartz stringers and veins occur in lime-silicate rock and some irregular pockets of high-grade gold ore occur in the quartz.

The principal development work is on the Sunrise group of claims. This development consists of 4 tunnels driven west in the shear zone along a fault slip in lime-silicate rock. The lower or No. 1 tunnel is driven S. 80° W., 275 ft. About 135 ft. west of the portal, there is a crosscut driven S. 10° W. 60 ft. It is stated that this crosscut for a distance of 60 ft. has an average value of $2.10 per ton in gold.

At 40 ft. in elevation above this tunnel, there is a tunnel driven west 100 ft. At 40 ft. in elevation above No. 2 tunnel, No. 3 tunnel has been driven west 75 ft., and No. 4 tunnel 125 ft. in length. Some high-grade ore was extracted from the upper tunnel. A pocket is reported to have been discovered from which $600 in gold was recovered. About 1500 ft. west of these workings, a shaft has been sunk on a quartz vein 8 in. in width on an inclination of 40° to a depth of 150 ft. Two high-grade pockets were encountered in these workings. Five tons of high-grade ore were treated in a small mill near the highway. Idle.

Tom Casey Mine. It comprises 6 claims situated in the Beveridge Mining District, at the head of Craig Canyon, on the east slope of the Inyo Range of mountains, 12 miles northeast of Lone Pine; elevation 8000 ft.; owner, Thomas Casey, Lone Pine, Calif.

The vein strikes E.-W., dip 60° N.; width, 12 in. to 4 ft. It occurs on contact of porphyry and limestone; developed by three tunnels at different elevations, the longest being 400 ft. on the vein.

Two men are employed.

Treasure Hill Mine. It comprises 12 claims situated in Wildrose Mining District, in the Panamint Range of mountains, 55 miles north of Trona; elevation, 5250 to 5800 ft.; owners, L. E. Mendelman, I. Kusnick, Paul Cores and Albert King, of Los Angeles, California.

Five parallel veins occur in a gneissoid granite; strike N.-S., dip 40° E. Widths vary from 12 in. to 4 ft. The vein quartz is mineralized with free gold, associated with pyrite and galena.

Development consists of shafts and tunnels, totaling 488 ft. A tunnel 152 ft. in length intersects a shaft sunk from the surface at a a depth of 65 ft. Ore extracted from these workings is said to carry $7.35 per ton in gold and silver. Idle.

Vin-Blanc Mine. It comprises one claim located in Coso Mining District, 6 miles southwest of Darwin, and 18 miles east of Olancha; owners, George C. Terry, H. F. Miers and C. W. Jones, of Independence.

The quartz vein is in granite; strike, NW.-SE.; dip. 80° SW.; width 6 in. to 2 ft.

Development consists of 2 shafts; one 100 ft. in depth, the other 80 ft. One ton of ore shipped to the Western Graphite Company's mill had an average value of 1.44 oz. in gold per ton.

Two men are employed.

Wahoo Mine. It comprises 2 claims, situated in the Argus Range, 6 miles north of Darwin, California; owner, Walter Hoover, Lone Pine, California; under lease to Paul Braun, Darwin, California.

This property adjoins the Ruiz Mine to the northwest. The country rock is limestone and quartz monzonite. The vein strikes N. 40° W.; dip 40° W.; width 3 ft. to 4 ft. The vein occurs in the monzonite.

Development consists of shaft sunk on the vein to a depth of 90 ft. A drift has been driven south on the vein for a distance of 80 ft. It is reported that 60 tons of ore were shipped to Burton Bros. Inc., at Tropico, California.

Equipment consists of 6-h.p. hoist and truck. Four men are employed.

Wonder Mine. It is situated in the Sarat[illegible] Ibex Mine, 10 miles southwest of Tecopa, on the east slope of [illegible] Argus Range of mountains; elevation, 3000 ft.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 85; XXII, p. 474.

Yucca Mine. It is situated in the Coso Mining District, 8 miles by road south of Darwin; elevation, 6000 ft.; owner, L. D. Owen, of Darwin, California.

A series of parallel quartz veins occur in granite; strike north and dip 30° east. Veins vary in width from 6 in. to 2 ft. There are two incline shafts sunk on one of the veins to a depth of 200 ft. These shafts are connected with drifts on the vein at 120 ft. and 165 ft. On other veins there are a number of shallow shafts from 10 ft. to 20 ft. deep, from which good ore has been shipped. The property has been worked off and on by the owner since 1908. Six tons of ore mined and shipped in 1937 are reported to have an average value of $36 per ton in gold.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 85; XXII, p. 474.

IRON

Deposits of iron occur in the Coso Range, and in the Slate Range. The ore from the iron deposits in Coso mountains was formerly used for flux at the Darwin and Keeler smelters in treatment of lead-silver ores from those districts from 1869 to 1877. The ore from the iron deposit in the Slate Range was formerly used as a flux at the smelter of the Modoc Mine, from 1880 to 1884.

Coso Iron Deposit. This deposit is situated on the north slope of the Coso Range of mountains, in the Coso Mining District, 12 miles east of Olancha; elevation, 5650 ft. Holdings comprise 22 claims, held by location; owner, G. W. Dow, of Lone Pine, California.

Iron-bearing veins occur in granite, varying from a few feet to 100 feet wide, and can be followed along their outcrops for a distance of 1000 ft. Several open cuts have been made on the croppings.

The ore is predominantly hematite, with occasional masses of magnetite. Much of the hematite contains disseminated magnetite. A considerable amount of the ore is very pure and high-grade, containing between 60% and 64% metallic iron, and less than 0.06% phosphorus. Analysis: Iron, 64.25%; phosphorus, 0.057%; silica, 4.49%; sulphur, 0.22%. It is estimated that this deposit contains 3,000,000 tons of commercial ore.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 87; XXII, p. 475.

Hoot Owl Iron Deposit. It is situated on the east slope of the Slate Range, 20 miles north of Trona; elevation, 2400 ft.; owner, Lloyd Helm, Inyokern, California; under lease to Bradley and Exstrom, 320 Market Street, San Francisco, California.

A massive outcrop of iron ore occurs in granite, with a strike of NE.-SW. It is 200 ft. in length and 50 ft. wide. The mineral is hematite, carrying 64% metallic iron with low phosphorus content; [illegible] in gold. Development consists of a 2-compartment vertical shaft 150 ft. deep in iron ore. About 500 ft. northeast of the shaft, there is a tunnel driven southwest 240 ft. The face of this tunnel is in ore. Ore is being hauled by truck to Trona, for shipment to San Francisco. To date they have shipped 150 tons.

Four men are employed.

Le Cyr Iron Deposit. It is situated on the north slope of the Coso Range, in the Coso Mining District, 15 miles southeast of Olancha; elevation, 5600 ft. Holdings comprise 6 claims held by location; owner, J. R. Le Cyr, Los Angeles, California.

A series of parallel veins of iron occur in granite. The ore is hematite and magnetite, reported to carry 59% metallic iron with less than 0.06% phosphorus. Estimated tonnage is said to be 1,300,000 tons. Analysis: Iron, 59.07%; silica, 3.04%; phosphorus, .047%; sulphur, 1.06%.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 475.

Roper Iron Deposit. This deposit is situated 7 miles east of Kearsarge, a station on the California and Nevada Railroad, on the west slope of the Inyo Range. The ore is specular hematite, said to carry values in gold.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 87; XVII, p. 282; XXII, p. 475.

LEAD, SILVER, ZINC

The earliest mining in Inyo County was that of the lead-silver ores in the southern part of the county, by Mormon colonists, previous to 1859. The principal productive silver-lead districts mentioned in order of their importance are:

Cerro Gordo District, which was discovered between 1862 and 1866 has been the largest producer of lead, silver and zinc ores in the state, and mining has been more or less active to date. The productive mines have been the Cerro Gordo, Cerro Gordo Extension (Royal), Estelle, Silver Reef and Santa Rosa.

The ores of the Cerro Gordo district consist of galena, lead carbonate, cerusite, anglesite, also some smithsonite, sphalerite, tetrahedrite and pyrite, with small amounts of gold.

The Cerro Gordo District has yielded to date over $17,000,000 (see Fig. 8).

Darwin District. The mining of lead-silver ores in this district has been from 1870 to date, and the approximate production has been between $3,000,000 and $5,000,000. The ore deposits are generally inclosed in lime-silicate rocks, and consist of argentiferous galena, with small amounts of pyrite and sphalerite. As a rule the galena is largely oxidized to lead-carbonate and sulphate. The productive mines have been Argus-Sterling, Christmas Gift, Custer, Defiance, Independence, Lucky Jim, Keystone, Thompson, and Wonder. In the past year the Darwin Lead Company acquired a lease on the Defiance-Independence-Thompson Group of mines, and installed a pilot concentration and flotation plant for the treatment of the low-grade ores from these mines.

In development work on lower levels of Defiance mines, leasers have developed 6 ft. of high-grade galena and lead-carbonate ore. This ore is being shipped to smelters at Salt Lake City, Utah. Shipments are reported to carry 40% lead with 20 oz. to 30 oz. in silver. Another important development made in the district in 1937 was the development of Keystone Mine by the Darwin Keystone Mining Company, and the shipment of a considerable amount of ore.

Tecopa District. This district which is situated in the Nopah Range in the southeastern end of the county has been an important producer of lead and silver ores. The principal productive mines in this district were the Gunsite, Noonday, Grant, and War Eagle formerly operated by the Tecopa Consolidated Mining Company. From 1912 to 1928 this company produced $3,000,000.

The principal production of *zinc ores* was from the Cerro Gordo Mine in the form of smithsonite. The main production was mined and shipped from 1911 until September 18, 1915. In the Darwin District on Zinc Hill, a considerable tonnage of zinc was shipped in 1914 and 1915 in the form of oxide of zinc and sphalerite. Other productive lead-silver deposits occur on the east slope of the White Mountains. The productive mines have been the Bunker Hill, Custer, Mineral Point (Sangar), Monster, and Montezuma.

Modoc District. This district is situated on the east slope of the Argus Range, 35 miles north of Trona, and 15 miles southeast of Darwin. The productive mines were the Minnietta, and the Modoc, which

properties were operated from 1880 to 1890. The Minnietta has been operated off and on until 1915, and during 1936. The mine was acquired under option by Ralph Merritt, of Independence, who started development work on the property in the hopes of developing the downward extension of the orebodies formerly worked. Some high-grade ore was developed, but no large orebodies discovered to date.

The Modoc Mine, was operated by the Modoc Consolidated Mines Company of San Francisco, and the production amounted to $1,900,000.

The Minnietta mine is said to have a production record of $1,000,000.

Slate Range District. This district is situated on the west slope of the Slate Range, 9 miles north and east of Trona, in the southern part of Inyo County. The Ophir Mine, and the Slate Range Mine (Copper Queen) were under operation during 1936 and 1937. The Ophir Mine is stated to have produced $800,000 and Slate Range Mine is said to have a production of about $900,000.

MINES

American Mine (copper-gold-silver). It is 12 miles southwest of Shoshone, a station on the Tonopah and Tidewater Railroad, on the eastern slope of the Black Mountains and 4 miles south of Sheepshead Springs. Holdings comprise 5 claims; owner, J. W. Stocker, Death Valley Junction, California.

The ore occurs in a narrow, barite vein in a thin, schist belt on a contact of monzonite and granite. The ore varies from a few inches to 2 ft. wide. Mineralization consists of argentiferous tetrahedrite, copper silicates and sulphides with a little gold.

Development consists of several tunnels, two of which are 800 and 200 ft. long, respectively. Above the 200 ft. tunnel is a stope 20 ft. long and 50 ft. high, to surface. Two men are employed.

Bibl.: State Mineralogist's Reports XV, p. 71; XXII, p. 476.

Argus-Sterling Mine (lead-silver). It is situated in the Darwin District, on the west slope of the Argus Mountains, 11 miles south of Darwin; elevation, 5850 ft.; owner, A. C. Taylor Estate, Gardena, California; Theo Peterson, agent, Darwin, California.

The vein, averaging 3 ft. in width, fills a fissure in limestone near a granitic contact. Shipments averaged 30% lead and 15 oz. of silver.

Developments consist of a 450 ft. tunnel and a 155 ft. shaft.

Bibl.: State Mineralogist's Reports XVII, p. 283; XXII, pp. 476-477.

Baxter Mine (lead-silver). It is situated in the Resting Springs District, 4 miles east of Evelyn, a station on the Tonopah and Tidewater Railroad, on the slope of Resting Springs Mountain; elevation 4000 ft.; owner, J. P. Madison, Shoshone, California.

Bibl.: State Mineralogist's Reports XV, p. 88; XVII, p. 283; XXII, p. 477.

Bedell Mine (Daisy Mine). The property comprises 8 claims, known as the *Le Roy Group,* situated on the east slope of the Inyo

Range of mountains, 14 miles southeast of Big Pine; elevation, 7500 ft.; owner, D. T. Bedell, of Big Pine, California.

Orebodies of galena and lead-carbonate occur along parallel fissures in the limestone. There are four mineralized fissures in the limestone that have been productive. These fissures strike N. 30° W., dip 45° E., and are about 40 ft. apart. The ore shoots developed vary in widths from 2 ft. to 4 ft.

The ore is galena associated with lead-carbonate, carrying $3 to $6 in gold; lead, 15% to 20%; silver, 15 oz. Selected ore shipped to the U. S. Smelting, Refining and Mining Company's smelter at Midvale, Utah, is reported to carry 40% lead, 30 oz. in silver, with gold values.

Development consists of a number of tunnels driven on the four fissures mentioned above. No. 1 tunnel is driven S. 30° E. 150 ft. At an elevation of 75 ft. above No. 1 tunnel, a shaft has been sunk to a depth of 50 ft. on a vertical fissure. On the west fissure an incline shaft has been sunk to a depth of 70 ft. with a drift 60 ft. southwest.

Mine equipment: 110 cu. ft. compressor, air drills, cars and trucks. Two men are employed on development.

Bibl.: State Mineralogist's Report XV, p. 94.

Belmont Mine (*lead-silver*). It is situated in the Cerro Gordo District, 11 miles northeast of Keeler and three miles by trail southeast of the Cerro Gordo Mine; elevation, 8000 ft.; owner, W. L. Hunter Estate, Keeler, California.

Argentiferous quartz veins occur in a crystalline rock of granitoid texture. The values are chiefly in silver with a percentage of lead. The silver minerals are tetrahedrite, argentite and stephanite. The veins vary from 8 in. to 6 ft. in width; strike is N. 75° W. and dip 60° to 70° SW.

Developments consist of a tunnel 400 ft. long and a shaft 150 ft. deep. There are about 3600 ft. of tunnels and drifts on the property.

Past production is said to be about $500,000.

Bibl.: State Mineralogist's Reports XVII, p. 283; XXII, p. 477.

Big Silver Mine (*Essex*). It is situated on the eastern slope of the Inyo Mountains, in the Ubehebe Mining District, one mile south of Hunter Creek, on the western edge of Saline Valley. The property is 50 miles by road north of Keeler, a station on the California and Nevada Railroad. Elevations range from 1600 to 3000 ft. Development consists of 3 tunnels, the longest being 240 ft.

The two groups of claims, known as the Essex and the Hudson, containing 120 acres, are owned by the *Big Silver Mining Company* and *National Silver Corporation;* Paul Bolton, trustee, Los Angeles; reorganization: *Saline Valley Mining Co.;* Paul Bolton, president; A. B. Ganfield, secretary, 247 S. Ardmore St., Los Angeles.

Bibl.: State Mineralogist's Report XXII, pp. 477-478.

Black Rock Group of Mines (*lead-silver*). It comprises 6 claims, located north of the Gunsite Mine on the western slope of the Nopah Mountains, 7 miles east of Tecopa; elevation, 2500 ft.

The ore occurs in irregular lenses along a fissure in the dolomite. It is principally carbonate of lead with some galena.

Development consists of 900 and 200 ft. tunnels with a raise from the lower tunnel into the shoot which was worked in the upper tunnel.

Bibl.: State Mineralogist's Report XXII, p. 479.

Blue Dick Mine. It comprises 4 claims situated in the Kingston Range of mountains, southeast of Tecopa, near the San Bernardino County line; owner, Henry Lang, Tecopa, California.

Lenticular masses of lead-carbonate ore occur along a fissure in limestone.

Development consists of 500 ft. of tunnels and drifts.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 89; XVII, p. 283; XXII, p. 479.

Bull Domingo Mine (lead-silver). It comprises 6 claims known as *Galena Group of Mines*, situated in the Pine Mountain Mining District, on the ridge southwest of Wyman Creek, about one-half mile west of Roberts Camp, in the White Mountains, 36 miles by road northeast of Big Pine; elevation, 8000 ft.; owner, P. N. Johnson, 302 E. Anaheim St., Long Beach, California. During 1934 the property was under lease and bond to P. N. Johnson, 355 Ocean Center Bldg., Long Beach, who operated the property until July, 1935.

The galena and lead-carbonate orebody with high silver values occurs along a contact fissure of limestone and schist; schist being the hanging wall and limestone the footwall. The contact fissure has a strike of N. 30° E., dip 60° E.; width varies from 6 ft. to 8 ft.; developed by a shaft 120 ft. deep with a drift 150 ft. in length on the 120-ft. level. Ore stoped to the surface for a length of 150 ft. At 200 ft. below the collar of the shaft, a crosscut tunnel was driven northwest 200 ft. intersecting the workings from the shaft. At 600 ft. in elevation below the shaft a cross-cut tunnel was driven N. 55° W., 600 ft. without intersecting fissure exposed in upper workings. The mine was reported to have been discovered in 1871 and worked by Mexicans, who had a small Vaso smelter at Roberts Camp. Idle.

Bunker Hill Mine. The property comprises 12 claims, situated 35 miles northeast of Big Pine, on the eastern flank of the Inyo Range of mountains, between Willow Creek and Keynote Canyon; elevation, 5500 ft.; owner, Bunker Hill Mining Co., Leo. Benjamin, president, 689 E St., San Bernardino, Calif.

The orebodies consist of irregular lenses of galena and lead-carbonate ore which occur in the limestone or on contact of limestone and porphyry. The ore that has been shipped from the property is reported to have carried from 30% to 60% lead, 33 oz. in silver and $4.50 in gold per ton.

Development consists of a shaft 600 ft. deep and a tunnel 400 ft. in length.

Equipment consists of 1500-ft. aerial tram from tunnel to mill. Mill equipment consists of 50-ton ore bin; 6 by 8 in. Blake crusher; revolving screen; and 3 concentrators. Mill driven by McCormick-Deering gas engine.

Two men employed on development.

California Queen Mine No. 4. It comprises a group of claims located 10 miles northeast of Trona, on the west slope of the Slate Range of mountains; owner, California Queen Mining Co.; C. S. McCarthy, Trona, Calif.

Bibl.: State Mineralogist's Report XXII, p. 479.

California Smelting & Refining Co.; F. W. Jackson, general manager; R. H. Lyon, superintendent. It is situated in Darwin Wash, about 5 miles east of Darwin. Consists of a 20-ton ore bin from which the ore is fed to a Wheeling jaw crusher set to ½ in., thence to 8 in. by 6 in. rolls, elevated by bucket elevator to ¼-in vibrating screen; oversize returned to rolls, undersize flushed to Western ore concentrator jig. Concentrates are shipped to Western Graphite Company at Lake Hughes. Jigs will be replaced by tables soon and the concentrates shipped to Selby. Power is a 15-hp. Fairbanks-Morse semi-Diesel engine. Water is obtained from a well in Darwin Wash and pumped to a 6000-gal. tank at the mill. The mill has treated about 100 tons in 1936-37, principally lead-carbonate ore tailings from the Darwin Lead Company and some ore bought from leasers on the Santa Rosa Mine.

Idle.

Campbird Group of Mines (silver). This property comprises the Campbird group consisting of 10 claims. It is in Jacob's Gulch north of Surprise Canyon, on the west slope of the Panamint Range, 11 miles northeast of Ballarat, and one mile west of Panamint City; elevation, 7300 ft.; owner, J. V. Leigh, 307 Union League Bldg., Los Angeles.

Two quartz veins, the Stewart Wonder and the Rainbow, varying in width up to 15 ft., occur in limestone. The Stewart Wonder vein strikes N. 75° W., dip vertical. The Rainbow vein has an easterly strike and dips 30° to 35° N.

Development consists of a crosscut tunnel driven north 25 ft. and drift east and west for a total distance of 400 ft. From this tunnel level a winze has been sunk to a depth of 150 ft. on the vein. The silver mineral occurring in the vein quartz is freibergite, a sulphantimonite of silver and copper.

Idle.

Bibl.: State Mineralogist's Reports XXII, pp. 479-480; XXVIII, pp. 359-361.

Carbonate Mine (Queen of Sheba), consisting of 7 claims, is on the east slope of the Panamint Mountains about 7 miles north of Warm Springs Canyon, on the west side of Death Valley about 40 miles northeast of Zabriskie, a station on the Tonopah and Tidewater Railroad; elevation 1200 ft; owner, *New Sutherland Divide Mining Company,* 156 Montgomery St., San Francisco; Dr. Thos. A. Stoddard, president; under lease to J. P. Madison, of Shoshone, California, who has been shipping for about 7 years.

The ores occur as replacements along the bedding planes of dolomitic limestone. The lenticular bodies strike a little E. of N. and dip 35° E. In the Carbonate Claim they occur along a length of about 400 ft. to a depth of 150 ft., having an average width of approximately 10 ft. and a maximum of 20 ft. Mineralization consists principally of lead-

carbonates with silver and a little gold. On the Queen of Sheba the ore is principally galena, carrying silver.

Shipments have aggregated approximately $300,000; the last 50 cars of which averaged 20% lead, 14 oz. of silver and $3 in gold. The ore on the Carbonate Claim has apparently been exhausted and work is now confined to the Queen of Sheba.

Development consists of a series of tunnels (all stoped) on the Carbonate Claim to a depth of 150 ft. and a long crosscut tunnel below which they failed to encounter any ore. On the Queen of Sheba a tunnel 1000 ft. long with a few crosscuts was formerly driven. No ore was developed. The present operator has crosscut W. about 40 ft., some 200 ft. above the old tunnel and has stoped some ore from 2 to 8 ft. wide, in drifts from the crosscut 100 ft. N. and 100 ft. S. In general, this ore is higher grade than the average shipments of the past.

The property is temporarily idle.

Bibl.: State Mineralogist's Reports XV, pp. 89-90; XXII, p. 480.

Cerro Gordo Mine. The property comprises 43 claims, about 550 acres, situated in the Cerro Gordo Mining District, near Cerro Gordo Peak, 8 miles by road east of Keeler; elevation, 8000 ft.; owner, Cerro Gordo Mines Company; F. J. Hambly, president; C. A. Stockton, secretary, San Jose, California.

Property in receivership: Receiver, Mordon H. Eddy, c/o W. I. Titus, Pacific Southwest Bldg., Los Angeles.

The Cerro Gordo Mine has been the most productive lead-silver mine in Inyo County, having yielded about $15,000,000. The mine was discovered in 1866 and worked continuously from 1869 to 1876, then periodically up to 1936.

The zinc orebodies were worked from 1911 until September 18, 1915. The property was idle from 1915 until 1923, when it was worked under lease by W. W. Waterson, of Bishop, until 1927. From 1928 until 1929 it was under lease to the *Estelle Mining Company;* Adolph Ramish, president; Roy C. Troeger, secretary and manager, Los Angeles, California.

A lease was secured on the mine in June, 1929, by the *American Smelting and Refining Company,* and this company operated the mine until April, 1933. During this period the ore mined and shipped by this company totaled over 10,000 tons with a gross value of $305,630. The approximate average grade of ore shipped was gold, .053 oz.; silver, 29 oz.; and lead 41%. The ore mined by this company was shipped to the Selby Smelting and Lead Company's smelter at Selby, California.

From May, 1935, to September, 1936, the property was under lease to the *Silver-Lead Syndicate;* J. J. Beeson of Salt Lake City, Utah, president, and Charles E. Trezona, secretary. During 1937 and 1938 the mine was idle.

GENERAL GEOLOGY

The Inyo Range is a long narrow, elevated fault block of relative recent age. Opposite Keeler, it is composed principally of Palaeozoic sediments; limestones, shales and quartzites, with minor amounts of

mesozoic shales and extrusives. These formations are invaded by numerous igneous dikes and sills, which are doubtless connected with larger intrusive masses exposed not far distant to the north. The sedimentary formations have been folded into an anticline of northerly-

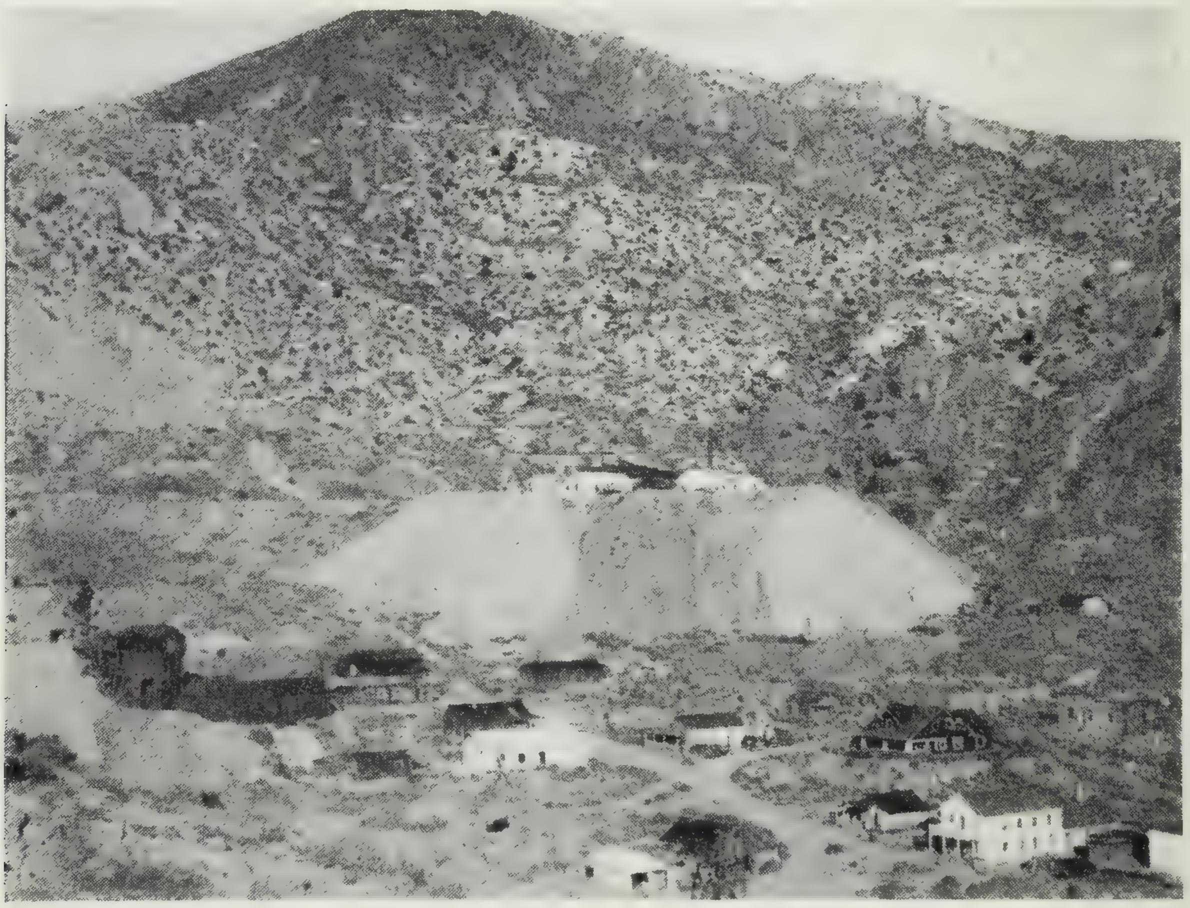


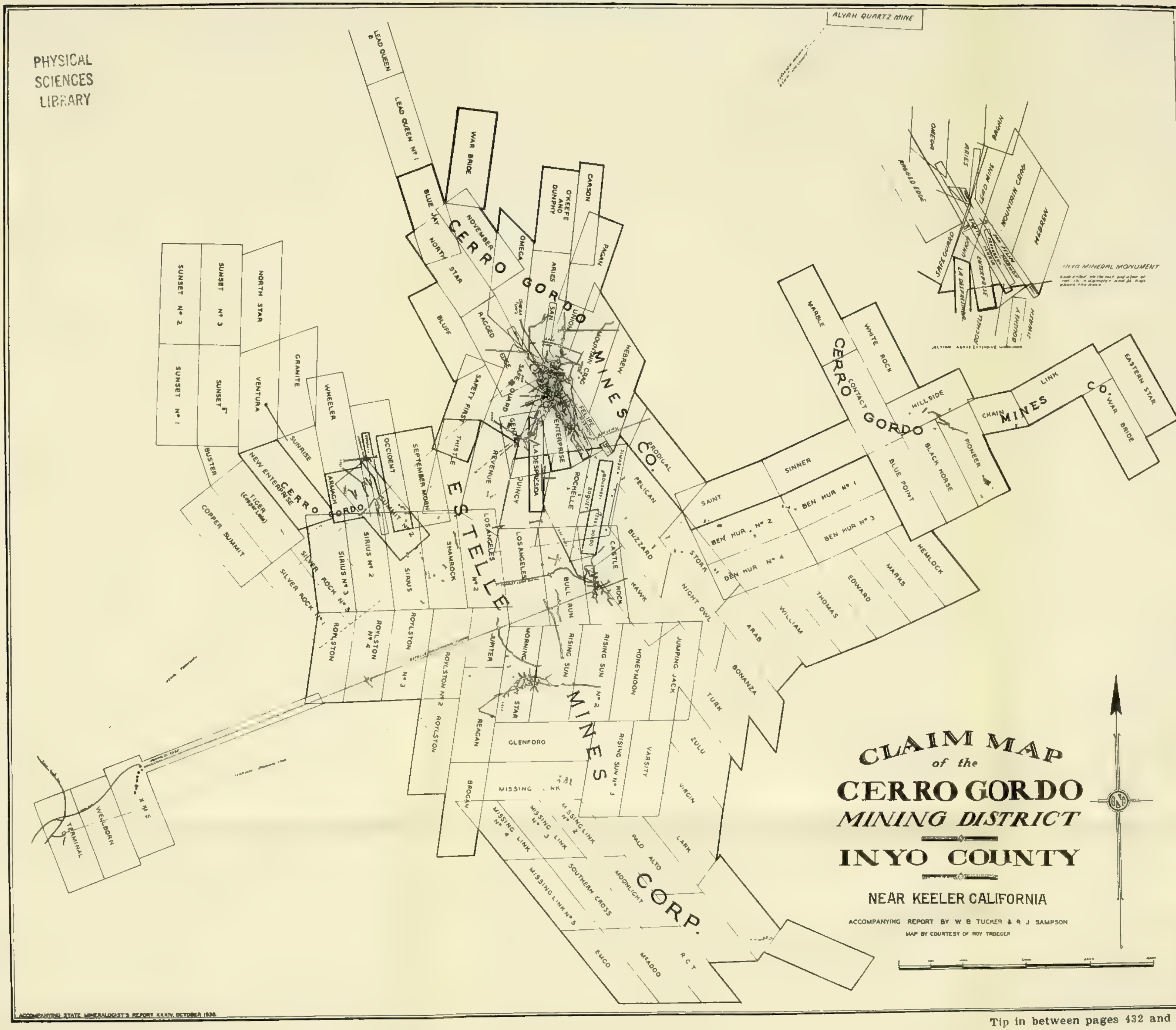
PHOTO. 8. Cerro Gordo Peak, Belshaw Shaft and Camp. Cerro Gordo, Inyo County.

southerly trend, the axis of which near the Cerro Gordo mine nearly coincides with the crest of the range. All the commercial orebodies of the property are confined to Devonian limestones. The sedimentary formations in the vicinity of the mine have been intruded by three series of igneous dikes, which, in order of age are monzonite porphyry, diabase, and quartz diorite porphyry.

Extensive faulting, both pre-intrusive and post-intrusive, pre-mineral and post-mineral has taken place in the mine and as some of the faults are of considerable displacement a complicated structure has been produced. Three periods of mineralization are recognizable in the mine; the earliest of pyrite; the second of argentiferous galena and sphalerite with some pyrite; and the last, quartz with subordinate amounts of galena and argentiferous tetrahedrite.

OREBODIES

Six orebodies were developed and mined in the Cerro Gordo Mine, known as the China stope, Jefferson, Diabase Dike, La Despreciada, Union, and Belshaw orebodies. These are of the silver-lead-zinc-iron type. The San Felipe and Santa Maria are argentiferous quartz veins, and although stoped in places during periods of high silver prices, are of secondary importance. The six orebodies are ore-chimney type, and have been formed by mineralized solutions ascending along joints and sheeting planes in the fracture zone in the Devonian limestone, creating pipe-like channels, in which the ore has been deposited. The



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Tip in between pages 432 and 433

rocks of the ore-bearing zone strike in a north to northwesterly direction, and dip on the average of 70° SW., the orebodies conforming to the trend of the inclosing rocks. The ore was mined through the Belshaw shaft, 900 ft. deep, with levels at 200, 400, 500, 700 and 900 ft. There is a winze from the 900-ft. level, 160 ft. north of the shaft sunk to a depth of 200 ft., from which drifts have been run on the 1000 and 1100-ft. levels. Total underground workings amount to about 15 miles (see Plate IV).

Idle.

Bibl.: State Mineralogist's Reports VII, p. 250; X, p. 213; XV, p. 94; XX, pp. 185, 187; XXII, pp. 480, 482; U. S. G. S. Bull. No. 540, pp. 97, 109; Professional Paper 110, pp. 106, 116.

Cerro Gordo Extension Mine (*Royal*). It comprises 7 claims, situated in the Cerro Gordo District, 9 miles east of Keeler; elevation, 8400 to 9000 ft.; owner, Mrs. R. C. Spear, Lone Pine.

Under lease and bond to the Cerro Gordo Extension Mining Company; J. P. Hart, president and manager; E. S. Hicks, secretary, Los Angeles, California.

This group of claims adjoins the Cerro Gordo Mining Company's property on the north. The formation consists principally of limestone with a belt of slates on the west slope of the ridge. On the Lead King and Lead Prince claims, there are three intrusions of diorite porphyry in the limestone that trend northwest. On the east slope of

PHOTO. 9. Belshaw Shaft, Cerro Gordo Mine, Cerro Gordo Mining District, Inyo County.

the ridge there is a belt of white marble that trends with the ridge. Three parallel veins occur in the limestone and strike N. 30° W. and dip 70° W. These veins vary in width from 12 in. to 3 ft.; average width is about 18 in. The ore occurs as lead-carbonate, with occasional

bunches of galena and zinc-carbonate with gold and silver values. The principal production of lead ore has come from the shaft on the Lead Queen claim, while the zinc production has come from workings on Lead King and Lead Prince claims. The principal development consists of a cross-cut tunnel on the Emperor claim, which at an elevation of 8400 ft. was driven east 1145 ft. No ore was developed in this tunnel. The principal development work is now confined to the Lead Queen claim, where the shaft has been sunk to a depth of 200 ft. on inclination of 70 degrees, with drifts on 50, 100, 150 ft. levels. The fissure strikes, N. 30° W. dip, 70° W.; width 18 in. to 3 ft. On the 50-ft. level, drift N. 75 ft. and S. 100 ft. On the 100-ft. level, drift S. 175 ft. and N. 100 ft. On 200-ft. level, drift S. 100 ft. and N. 50 ft. also crosscut E. 50 ft.

Recent ore shipped to the United States Smelting, Refining and Mining Company's smelter at Midvale, Utah, carried the following values: Gold, 0.115 oz.; silver, 15.40 oz.; copper, 0.55%; lead, 20.20%; zinc, 3%.

Mine equipment consists of 300-cu. ft. compressor, 15-h.p. hoist, jack-hammers, truck.

Four men are employed on development.

Bibl.: State Mineralogist's Report XXII, pp. 497-498.

Cerrusite Mine (*silver-lead*). It comprises 6 claims in the Lee Mining District, on the west slope of the Hunter Mountain, about 37 miles via the Saline Valley road from Keeler; owner, W. A. Reid, of Keeler, and under lease to Chauncy Lee, of Keeler.

The vein is in limestone and strikes northeast-southwest and dips about 40° N. Development consists of 3 tunnels 200 ft. long at 100 ft. intervals. Values are reported from $12 to $25 per ton, chiefly silver.

Idle.

Chesamac Mine (lead-silver). It comprises 6 claims situated in the Wildrose Mining District, on the east slope of the Panamint Range of mountains, 18 miles northeast of Ballarat; owner, Donald MacDonald, of Los Angeles, California.

Idle.

Bibl.: State Mineralogist's Reports XXII, p. 482; XXVIII, page 361.

Christmas Gift Mine. It is situated in the Darwin District, 2 miles north of Darwin; elevation, 5300 ft. Holdings consist of 5 claims; owners, W. L. Skinner and J. C. Boe, Darwin, California.

Idle.

Bibl.: State Mineralogist's Reports VIII, p. 226; X, p. 211; XVII, pp. 284-285; XXII, p. 482; U. S. G. S. Bull. 580-A, pp. 10-12.

Cliff Mine. It comprises 6 claims situated in the White Mountains, in the Deep Springs District, 5 miles south of Oasis.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 93; XXII, p. 482.

Columbia Mine. It is situated in the Darwin District; owner, Wagner Assets Realization Corporation, Chicago, Ill. Idle.

Bibl.: State Mineralogist's Reports XXII, p. 482; U. S. G. S. Bull. 580, pp. 17-18.

Custer Mine (lead-silver-copper). It is situated in the Darwin District, one mile east of Darwin; owners, Frank Long and Charles Grimes, Pasadena, California.

The ore, principally lead-carbonate and galena, is found in bunches in a large irregular body of coarsely, crystalline calcite.

Development consists of a shaft 400 ft. deep. Reported production is over $250,000.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 94; XVII, p. 285; XXII, p. 483; U. S. G. S. Bull. 580, pp. 15-16.

Custer Mine (lead-silver). It comprises 6 claims known as Custer No. 1, No. 2, No. 3, No. 4, No. 5 and No. 6 situated on east slope of the Inyo Range of mountains, 16 miles northeast of Independence; elevation, 5000 ft.; owner, Dr. J. G. Baxter, Independence, California.

The ore is lead-carbonate and galena with silver and gold values. It occurs on contact of limestone and granite. Strike of contact is N. 40° E., dip 40° NW. Width is 4 to 6 ft.

Development consists of two tunnels, upper tunnel being 50 ft. in length, and lower tunnel is 100 ft. in length. The mine has been worked off and on since 1926, producing some high grade gold-lead-silver ore.

Shipments carried 2 oz. to 3 oz. in gold, 30 oz. to 80 oz. in silver, with 35% lead and 5% copper. Ore has to be packed on animals over range of mountains to Mazourka Canyon, then hauled by truck to Kearsarge, a station on narrow gauge branch of the Southern Pacific Railroad. Shipment costs to U. S. Smelting, Refining and Mining Company's smelter at Midvale, Utah, amount to $50 per ton. Four men are employed.

Darwin Cyanide Plant. It is situated in the Darwin Wash, 4 miles south of Darwin, operating on tailings from the Darwin Lead Co. Richard Wallace has a lease on the tailings, and has given a sub-lease to Louis Warmkin, Darwin; Fritz Schwram, superintendent.

The plant consists of steel tanks 8 by 10 by 4½ deep; capacity 18 tons; one water tank, capacity 5000 gallons and one cyanide solution tank, capacity 5000 gallons. Tailings are leached for 6 days in a solution containing 2½ lb. of sodium cyanide per ton of water and precipitated in 6 barrel-type zinc boxes. Barren solution flows to sump tank and is pumped back to the solution tank by a centrifugal pump. Water is secured from a well in Darwin Wash. Heads are reported to carry $3 per ton in silver.

Darwin-Keystone Mine (silver-lead). It consists of 25 claims in Sec. 24 and 25, T. 19 S., R. 40 E. and Sec. 19 and 30, T. 19 S., R. 41 E., Darwin Mining District, on the east slope of the Argus Range, about 3 miles east of Darwin; A. A. Rubel, Pres.; Mrs. A. A. Rubel, Sec.-Treas.; A. Yoder, Supt.

Developed by the Keystone tunnel, elevation 4700 ft., driven west about 375 ft. and the McDonald tunnel 291 ft. above and 88 ft. south, driven 135 ft. west. Near the face of the Keystone tunnel, a crosscut was driven south 88 ft. and a raise in ore driven to connect with the McDonald tunnel. A vertical winze 6 by 12 ft. was being sunk in ore near the face of the Keystone tunnel and was down 50 ft. in October, 1937.

The ore is chiefly lead-carbonate, occurring in lenses and chimneys in blue limestone, associated with red and brown oxides of iron. About 800 tons of sorted ore from the raise and winze shipped to Salt Lake City is reported to have averaged $35 (15% Pb, 28 oz. Ag and $1.25 Au).

Equipment consists of a 180-h.p. Fairbanks-Morse diesel engine, 150 KVA generator, Worthington 440-cu. ft. compressor, U. S. 75-h.p. motor; Rix VI, 120-cu. ft. portable compressor; and a Kohler 5 KVA 110-volt light plant. A 1600-ft. jig-back tram with two 1000-lb. capacity buckets carries the ore from the bins at the tunnel portal to the loading bins at the camp. An electric power line runs from the generator to the tunnel for light and power. A 3 in. air line delivers air to a 10 ft. by 24 in. diam. receiver at the portal.

The camp has 16 one-room cabins, change house, recreation hall and commissary and offers modern accommodations for about 45 men. All buildings are new and built of corrugated iron. Water is obtained from a well in Darwin Wash, about 3 miles distant where they have a water right to 0.075 cu. ft. per second.

Ten men are employed on development.

Defiance, Independence, and Thompson Mines, which include a total of 66 claims 20 patented and 46 unpatented claims, are situated in the Darwin Mining District, 2 miles north of Darwin, in Sec. 13, 23 and 25, T. 19 S., R. 40 E., M. D. M.; elevation, 5100 to 5600 ft.; owner, *Wagner Assets Realization Corporation*, of Chicago; under lease to *American Metals, Inc.* The *Darwin Lead Company* has subleased from the last-named company. Officers of the Darwin Lead Company are Col. H. R. Montgomery, secretary-treasurer, and H. E. Olund, vice president and general manager.

The orebodies occur chiefly as replacement deposits along the bedding planes of a hard, silicified limestone at or near its contact with a quartz-diorite. Their general trend is N. 45° W., dip 35° SW., and the widths vary from 6 to 20 ft. On the hanging-wall side, the ore consists principally of galena in massive calcite, while on the footwall it is largely lead-carbonate. As previously mined, it is said to have averaged 12% lead and from 8 oz. to 10 oz. of silver per ton. The present operators estimate some 80,000 tons above the Thompson tunnel which averages 6% lead and 8 oz. of silver per ton.

Development on the Defiance consists of a shaft sunk on a 35° inclination for 500 ft. with levels at intervals of 100 ft. The orebody was worked for about 500 ft. in length. It is reported that recent work on the lower levels has opened a new orebody from 4 ft. to 6 ft. wide; shipments carried 40% lead and 20 oz. of silver per ton. Defiance has been sub-leased to Paul and William Braun, of Darwin, by Darwin Lead Co., shipping 50 tons per month.

The Thompson is developed by a tunnel driven northwest 1000 ft. At 450 ft. from the portal it encountered an ore shoot 100 ft. long and 30 ft. wide. Two raises have been driven from this tunnel to the intermediate and Defiance levels.

The Independence has been opened by two tunnels, 200 ft. and 150 ft. long, respectively.

The mines are equipped with machine shop, carpenter shop, electrical shop, assay laboratory, warehouse, bunk houses and five staff houses.

Ore from Thompson tunnel is dumped into 75-ton bin at portal, passed through 12 by 20-in. jaw crusher and over one in. shaking screen, undersize to bin by 20-in. conveyor. Trucks haul it to 50-ton bin at the tram terminal. An aerial tram one mile long conveys it to the 100-ton mill bin. From bin by belt feeder to 20-in. conveyor to 30-in. by 14-in. rolls crushing to $\frac{1}{4}$-in.; classifier delivers coarse material to a Bendelari jig with $\frac{3}{4}$-in. screen; tailings and middlings to 30-in. by 14-in. rolls, set at $\frac{1}{8}$ in.; thence to classifier, coarse ore to jig, 16-in. slotted screens, to classifier, dewatered tails to dump, middlings to 50-ton mill bin, thence by belt feeder to 3 ft. by 8 ft. rod mill in closed circuit with duplex Dorr classifier, overflow to 2 thickeners (in series), thickened slimes to conditioner, thence to two 6-ft. and one 10-ft. K. & K. flotation cells, concentrates to thickener and filter, flotation tails to Diester-Plato table. Mill has about 100 tons capacity. Extraction has not been satisfactory and the plant is shut down, pending results of research work on the ore.

Bibl.: State Mineralogist's Reports VIII, p. 226; X, p. 211; XV, p. 98; XVII, pp. 287-288; XXII, p. 483, 486, 487. Reports of Director of the Mint, Precious metals in U. S. 1883, p. 164; 1884, p. 103; U. S. G. S. Bull. 580, pp. 14-15.

Ella Group of Mines. It comprises 8 claims held by location situated in the Cerro Gordo District, one mile north of the Cerro Gordo Mine and 7 miles east of Keeler; elevation 7000 ft.; owner, William Betts, 331 W. 31 St., Los Angeles.

The ore occurs in irregular lenses of galena and lead-carbonate along two well-defined fissures in Devonian limestone which trend NW. and dip 70° NE. Developments comprise two tunnels, with a total of 2500 ft. of drifts. No. 1 tunnel is 300 ft. in elevation below the outcrop of the veins and No. 2 tunnel is 300 ft. in elevation below No. 1 tunnel and is 600 ft. in length.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 483.

Estelle and Morning Star Mines. The property comprises 71 claims with an approximate total of 1400 acres, situated in the Cerro Gordo Mining District, on the west slope of the Inyo Range of mountains, 5 miles east of Keeler, the terminal of the Owens Valley narrow gauge at Owenyo, 17 miles north of Keeler; elevation 6200 to 8000 ft.; owner, Estelle Mining Corp.; Adolph Ramish, Pres.; Roy C. Troeger, Sec. and Mgr., Los Angeles; under lease to *Morning Star-Keeler Gold Mines Lease;* Dr. R. B. Denton, Trona, Calif., and Lawson Linde, Keeler, Calif. (see Plate VIII)

PHOTO. 10. Panorama View—Estelle Mine Corporation Properties—Keeler, Inyo County, California.

At an elevation of 6290 ft. the Dellaphine tunnel has been driven N. 70° E. 8100 ft., intersecting the Morning Star vein at a depth of 1700 ft. At 7676 ft. from the portal, cut the San Felipe vein which is developed in the Cerro Gordo Mine at a depth of 2401 ft. The San Felipe vein strikes N. 35° W.; dip 70° SW. At 6942 ft. from the portal of the tunnel, intersected the Santa Maria vein, also worked in the Cerro Gordo Mine. The Santa Maria vein strikes N.-S.; dip 60° E.

DEVELOPMENTS:

Drifting on main tunnel level	4783 ft.
Main raise	800 ft.
140-ft. level from raise	1360 ft.
340-ft. level from raise	602 ft.
660-ft. level from raise	2456 ft.
Total	9957 ft.
Main tunnel	8070 ft.
Total underground workings	18027 ft.

At 7500 ft. from the portal of the tunnel is an 800-ft. vertical 2-compartment raise, with levels at 140 ft., 340 ft. and 660 ft. The face of the north drift on the 660-ft. level is 776 ft. below the Cerro Gordo 900-ft. level and 340 ft. below the Cerro Gordo 1100-ft. level. The principal tonnage of ore mined on the main tunnel level was from two stopes on the San Felipe vein. The length of these stopes along the strike of the bedding of the limestone is 150 ft., with 40 ft. above the level. Width of stopes is from 3 ft. to 7 ft. The ore was largely galena with some lead-carbonate. The ore mined from stopes on the 140, 340 and 660-ft. levels was principally galena and lead-carbonate; reported to carry 30% lead and 30 oz. in silver per ton. The production of ore from the Estelle tunnel level from 1916 to 1926 was 2700 tons with an average value of 0.16 oz. in gold and 20.8 oz. in silver and 21.61% in lead, with a total value of $80,146.

Morning Star Mine. The Morning Star workings are situated 4600 ft. due south of the Cerro Gordo shaft; elevation 7700 to 7900 ft.

The orebodies developed in the Morning Star Mine occur in the Devonian limestone and marble, called the Cerro Gordo Formation. This formation has a thickness of about 1500 ft. and outcrops continuously from the Cerro Gordo Mine to a point south of the Morning Star workings, where it disappears beneath the overlying White Pine shale formation of the Mississippian age.

The principal orebody cut on the 1700-ft. tunnel level is known as the Gold stope orebody, due to the fact that the ore mined carried 0.80 oz. in gold. This orebody was found on a bedding in the limestone with a strike of N. 50° W.; dip 45° SW. The vein filling is iron. The stope is about 70 ft. in length and its thickness varies from 3 ft. to 10 ft. The ore mined had an average assay value of 0.80 oz. in gold, 30.67 oz. in silver, 5.55% lead and 25.7% iron. The lead-zinc orebodies worked in the Morning Star Mine were developed from the winze from the 1700-ft. tunnel level to the 1400-ft. level. The general strike of the orebodies was N. 30° W., dipping 70° W. The ore mined is iron-stained, siliceous ore carrying values in silver.

Ore extracted from the Morning Star workings is reported to have been 6000 tons of ore with a gross value of about $150,000.

Developments: The mine has been developed by two tunnels. At an elevation of 7972 ft. the upper tunnel (1700-ft. level) has been

driven east 1530 ft. The lower tunnel (1400-ft. level) is 218 ft. vertically below the upper tunnel and at an elevation of 7754 ft. is driven east 930 ft. (see Plate IV).

These two tunnels are connected by a winze sunk on an inclination of 80°, from which sub-levels have been driven which are called the 1450, 1500, 1550 and 1600-ft. levels The vertical distances below the 1700-ft. level are 150, 100, 70 and 40 ft.

Development, exclusive of raises, winzes and stopes, totals about 6400 ft. Ore from the Morning Star Mine is being mined and shipped to Keeler Gold Mine mill for treatment.

Six men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 108-109; XVII, p. 286; XX, pp. 187-189; XXII, pp. 483-484; U. S. G. S. Bull. No. 540, p. 110; U. S. G. S. Professional Paper 110, pp. 116-117.

Fairbanks Mine. It comprises 8 claims situated in the Darwin District, 3 miles north of Darwin and northwest of the Lucky Jim Mine; elevation, 5500 ft.; owner, Alex Rouna, Darwin, Calif.

The fissure in lime-silicate rock strikes northwest. The width varies from 2 ft. to 4 ft. The ore is galena with lead-carbonate. The fissure is developed by a shaft 150 ft. in depth. Mine equipment consists of a 6-h.p. gas engine hoist. Two men are employed.

Fernando Group of Mines. It comprises 7 patented claims, known as Fernando and St. Charles, situated in the Darwin District, in Sec. 24, T. 19 S., R. 40 E., M. D. M., one mile east of Darwin, adjoining the Custer and Jackass mines on the east; elevation, 4850 ft.; owner, *Coso Copper Company;* F. H. Long, president, Pasadena, California; under lease to Theo Peterson, Darwin, California.

The orebody occurs as irregular lenses of lead-carbonate and galena on contact of diorite and lime-silicate rock. The vein trends east and dips 40° N. Width of vein is from 3 ft. to 4 ft.

Idle.

Bibl.: State Mineralogist's Report XXII, pp. 484-485.

Gibraltar Mine (*Big Horn*). It comprises 4 claims situated in the South Park Mining District, 7 miles southeast of Ballarat; elevation, 7000 ft.; owner, John Thorndike, Ballarat, California.

The ore occurs as irregular lenses of lead-carbonate and galena in a fissure in the limestone. Shipments are said to have carried 30% lead and 20 oz. of silver per ton.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 95; XXII, p. 485; XXVIII, p. 361.

Gunsite Mine is in the Nopah Range, 7 miles east of Tecopa; elevation, 2350 ft.; owner, *Tecopa Consolidated Mining Co.;* L. D. Godshall, vice president and general manager, 722 South Oxford Ave., Los Angeles, California.

There is a railroad from this property and the Noonday to Tecopa, where it connects with the Tonopah and Tidewater.

The country rock is the Silver Rule dolomite which is underlain by Algonkian shales and conglomeratic sandstones. The ore occurs as irregular lenses of lead-carbonate and galena, along a fissure in the dolomite which strikes N. 45° W. and dips 35 to 50° NE. A series of

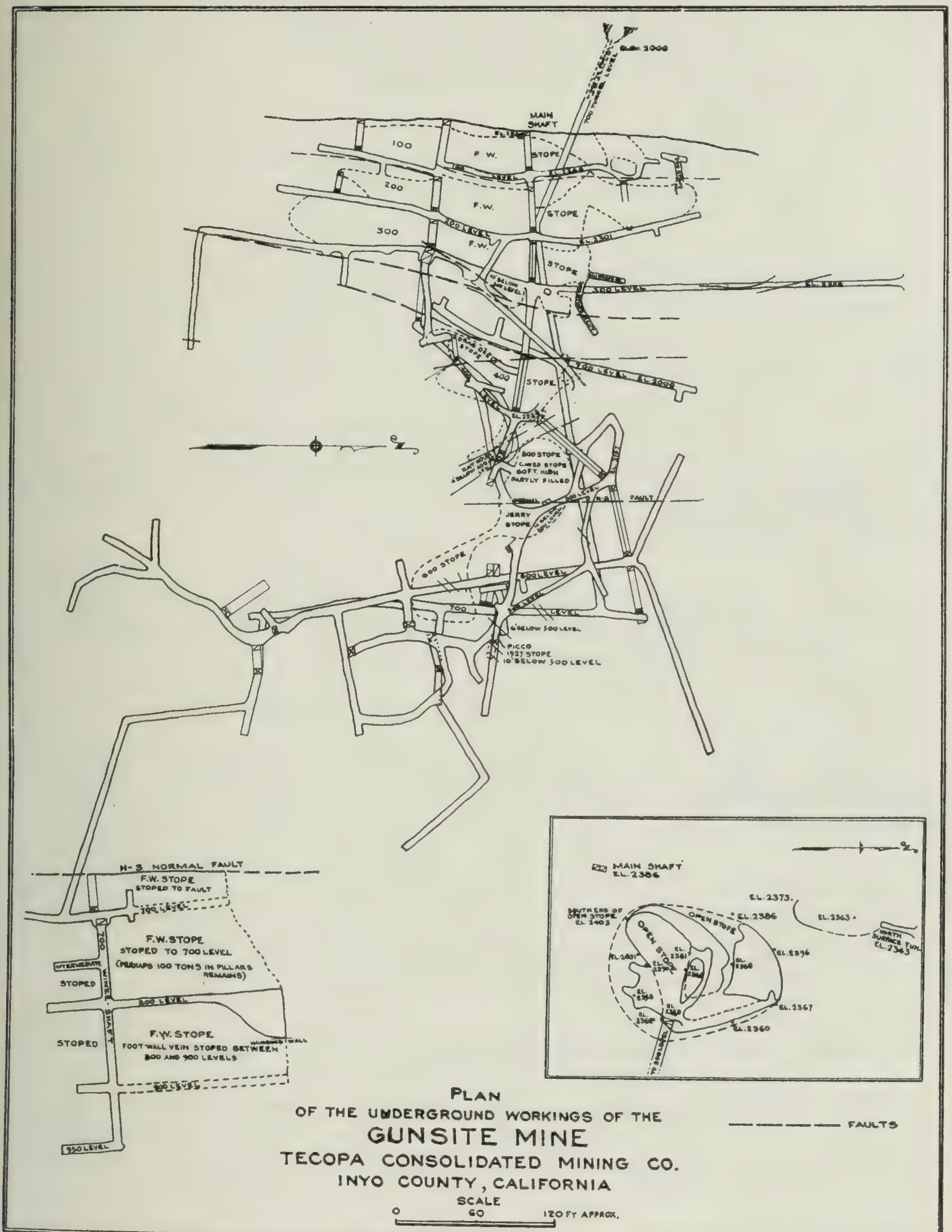


FIG. 8.

N.-S. faults, dipping from 35 to 55° W., show displacement of the ore-bodies up to 30 feet.

Development, consisting of several thousand feet, is shown on a map published herewith.

During its period of operation, 1912-1928, some 55,000 tons of ore was shipped to the smelters. This ore ranged from $6 to $50 per ton in value. The average assay value of all shipments was: gold, .077 oz.; silver, 9.38 oz.; lead, 7.84%. Shipments of the lower grade ore were made possible through cooperation of the smelter which needed this class of ore in their charges. All of this ore was taken from one shoot, as indicated on the map. Since the company ceased its operations an occasional carload has been shipped by leasers.

Idle at present.

Bibl.: State Mineralogist's Reports XV, pp. 95-96; XVII, pp. 286-287; XXII, p. 485; Report of the Director of the Mint, Precious Metals in the U. S., 1883, p. 166.

Ignacio Mine (*formerly Ygnacio*) (*lead-silver*). It comprises one patented claim situated in the Cerro Gordo District, on the west slope of Inyo Range of mountains, 6 miles east of Keeler; elevation, 7800 ft.; owner, *Cerro Gordo Mines Company,* San Jose, California.

A vein of quartz occurs in lime-silicate rock, strikes N.-S.; dip E.; width 8 ft to 10 ft.; developed by shaft 500 ft. in depth and tunnel driven south 2000 ft. on vein; workings caved. The ore mined was galena with lead-carbonate, reported to carry 30% lead with 20 oz. to 30 oz. in silver per ton.

Idle since 1916.

Bibl.: State Mineralogist's Reports XV, pp. 97-98; XVII, p. 287; XXII, 485; R. W. Raymond, Mineral Resources West of the Rocky Mountains, 1870, p. 17.

Independence and Thompson Mines (see Defiance Mine).

Jackass Mine. It is situated in the Darwin District, one mile northeast of Darwin, on the east flank of the Darwin Hills; elevation, 5000 ft.; owner, Black Metal Mining Company, Los Angeles.

The ore deposit occurs in mineralized zone 45 ft. in thickness in lime-silicate rocks; strike NW.-SE., dips 70° SW.. The ore is galena and lead-carbonate with some sphalerite, and is said to carry 12 to 15 oz. silver and 4 to 6% lead; developed by an incline shaft to a depth of 140 ft. with drifts northwest and southeast on the fissure.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 288; XXII, p. 487.

Kane Group of Mines. It comprises 15 claims situated on the northeast slope of the Slate Range, 12 miles north of Trona; elevation, 3900 ft.; owner, Belcher Extension Consolidated Mines Company, Jersey City, N. J.

Idle.

Bibl.: State Mineralogist's Report XXII, pp. 487-488.

Lane Mine. It is situated in the Darwin District, two miles northeast of Darwin, on the east flank of the Darwin Hills; elevation, 4100 ft.; owner, Wagner Assets. Realization Corp., of Chicago; under lease to American Metals Inc.; sub-leased to the Darwin Lead Company; H. E. Olund, vice-president and manager.

Bibl.: State Mineralogist's Reports XII, p. 24; XIII, p. 32; XV, pp. 98-99; XVII, p. 288; XXII, p. 488; U. S. G. S. Bull. 580.

Leadfield District

The Leadfield District is located in Lost Valley in T. 12 S., R. 45 E., M. D. B. & M. in the Grapevine Mountains of the Amargosa Range, 22 miles westerly from Beatty, Nevada; elevation, 3950 ft. to 5200 ft. The ore deposits occur in a belt of limestone that strikes N. 30° W. The limestone is folded and the beds strike and dip 60° N. At various points for a distance of about 2 miles galena occurs disseminated in hard, blue limestone, and along certain bedding planes of the limestone replacing calcite. The principal mineralization of lead-zinc occurs where north-south fractures intersect bedding planes of the limestone. The orebodies exposed carry from 5% to 7% per cent lead, with 5 oz. silver, and 5% to 6% zinc.

The Leadfield District was active in 1925-1926 but since that date has been dormant.

Bibl.: State Mineralogist's Report XXII, pp. 504-510.

Lee Mine. It comprises 6 claims situated in the Lee Mining District, 18 miles east of Keeler; elevation, 5000 ft.; owners, Franklin Booth and W. A. Reid, of Keeler, California; under lease to B. F. Shively and John Hopkins.

A series of parallel veins occur in a mineralized zone in the limestone. The mineralized zone is about 400 ft. wide and 1000 ft. in length, with an E.-W. strike, dipping 70° N. The ore is in the form of chlorides; chloro-bromides of silver, argentite and occasional bunches of galena are found filling fractures that cut the bedding planes in the limestone. Developments consist of several shafts sunk to a depth of 80 ft. with about 1000 ft. of underground workings. During 1937, 250 tons of ore was shipped, reported to have a net value of $49 per ton in silver.

Three men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 99-105; XVII, p. 289; XXII, p. 488; Report of the Director of U. S. Mint, Precious Metals in U. S., 1883, p. 163.

LeMoigne Mine. It comprises 12 claims situated in the LeMoigne Mining District, on the east slope of the Panamint Range, 15 miles southwest of Stove Pipe Wells and 50 miles by road west of Beatty, Nevada; elevation, 4950 to 5700 ft.; owner, *Buckhorn Humboldt Mining Company,* W. R. McCrea, Reno, Nevada.

Massive galena and lead-carbonate occur in irregular lenses along fissures in the limestone. The fissures strike N.-S., dipping 65° W. Ore shipped from the property in the past is reported to carry 50% lead with 5 oz. in silver per ton.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 488.

Lincoln Mine (Silver Dome). It comprises 6 claims situated in the Deep Springs Mining District, 4 miles north of Deep Springs Ranch on the Midland Trail and 25 miles northeast of Big Pine; eleva-

tion, 6200 ft.; owners, A. T. Wilkerson and B. W. Holeman, of Bishop, California.

A series of narrow fissure veins occur in granite. Widths vary 6 to 12 in.; strike E.-W.; dip 65° N.; developed by a number of shafts sunk on the veins to depths of 50 ft. to 100 ft. Some high-grade silver ore shipped is reported to carry from 100 oz. to 300 oz. in silver per ton.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 289; XXII, pp. 488-489.

Long John Mine. It comprises 7 patented claims, situated on ridge south of Long John Canyon on the west slope of the Inyo Range, 8 miles east of Lone Pine; elevation, 5900 ft.; owner, James A. Walker, 1201 N. Isabel St., Glendale, California.

The property was formerly owned and operated by the Inyo Lead Syndicate, of Las Vegas, Nevada, and operated from 1925 to 1926. The grade of ore shipped was reported as containing 40% lead, with 40 oz. in silver per ton, reported production being $60,000. Orebodies occur along a fissure in limestone; strike N. 30° W., dip 60° E.; width 4 ft. to 6 ft. The ore is galena and lead-carbonate with silver values; developed by shafts and tunnels.

Idle.

Lucky Jim Mine. It comprises 18 patented claims known as Lucky Jim group, situated in the Darwin District two miles north of Darwin and 24 miles southeast of Keeler; owner, *Wagner Estate Corporation,* of Chicago; under lease to *American Metals, Inc.,* Darwin, California; elevation, 5000 ft. Development consists of a vertical shaft 300 ft. deep, then a winze from 300-ft. level 450 ft. in depth to 750-ft. level, with about 10,000 ft. of drifts and cross-cuts. The shaft was sunk on a fissure that cuts across the beds of the limestone. The course of the fissure is N. 50° E. with a dip of 80° W. Width of ore mined was 4 ft. to 6 ft. Workings are caved, no equipment on property. Mine produced over $2,000,000.

Idle.

Bibl.: State Mineralogist's Reports VII, p. 226; X, p. 211; XII, p. 24; XV, pp. 100-101; XVII, pp. 289-290; XXII, p. 489; Mineral Resources West of Rocky Mts., 1876, p. 25; Report of Mint, Precious Metals in U. S. 1883, p. 163; U. S. G. S. Bull. 580, pp. 12-18.

Mineral Hill Group of Mines. This group comprises 11 claims located on east slope of the White Mountains, in Sec. 29, T. 8 S., R. 36 E., 17 miles by road northeast of Big Pine. Elevation, 6500 ft.; owners, R. W. Swank and L. Ludwick, of Big Pine, California.

Bibl.: State Mineralogist's Report XXII, p. 489.

Mineral Point Mine (Sanger Mine). It comprises 7 claims, located in Secs. 13, 14, 23, 24, T. 7 S., R. 34 E., on the west slope of the White Mountains, on a ridge two miles south of Black Canyon and 14 miles east of Bishop; elevation, 8200 ft.; owners, Chas. W. Bretz and Flynn Bros., Bishop, California.

In 1925, 600 tons of high-grade lead-silver ore was shipped from the property.

Idle.

Bibl.: State Mineralogist's Report XXII, pp. 489-490.

Minnietta Mine. The property comprises the following claims: St. Charles, St. John Dividend, St. Arthur, Helen G. and St. John Millsite, totaling 105 acres, situated T. 19 S., R. 42 E., in the Modoc Mining District, on the east slope of the Argus Range of mountains, 30 miles north of Trona and adjoining the Modoc Mine on the south; elevation, 3000 ft. to 4000 ft.; owner, Mrs. Jack Gunn, Independence, California; under lease and bond to Ralph Merritt, Los Angeles.

The property was discovered in 1889 and has been worked off and on to date. The reported production of the mine is said to have been over $1,000,000.

The orebodies occur in fissures in limestone and on bedding planes of the limestone which are cut by diabase, intrusive dikes. The principal mineralization occurs on the hanging wall of diabase dikes. These dikes are from 10 ft. to 25 ft. thick. The fissures strike N. 50 to 60° W. and dips 35° S. The width of the orebodies worked was 5 ft. to 20 ft., the ore being argentiferous galena, silver chloride and chlorobromides, said to carry $\frac{1}{4}$ oz. in gold, with 30% to 50% lead, and 50 oz. to 200 oz. in silver.

Development consists of 6 tunnels and 3 shafts. At an elevation of 2000 ft., the lower tunnel No. 1 is driven south 2700 ft. with a drift along a diabase dike 600 ft. in length. Other tunnels are 50 ft. to 200 ft. in length. Below Jack Gunn stope, a shaft is sunk on an inclination of 35° to a depth of 340 ft. At 200 ft. in depth the ore is cut off by thrust fault. On 165-ft. level, drift north 150 ft. and south 147 ft.; on 220-ft. level, drift north 50 ft. and south 50 ft.; on 330-ft. level, drift south 75 ft. A small lens of ore was developed on 165-ft. level. (See Plate V.)

Mine equipment consists of 18-h.p. gas engine hoist; portable Ingersoll-Rand compressor, 300 cu. ft. capacity; 1-ton ore skip; trucks; blacksmith shop.

Six men are employed.

Bibl.: State Mineralogist's Reports X, p. 212; XV, p. 101; XVII, p. 290; XXII, p. 490; R. W. Raymond, Mineral Resources West of Rocky Mountains, 1876.

Modoc Mine. It comprises 8 patented claims, totaling 160 acres, situated in T. 19 S., R. 42 E., on the east slope of the Argus Range, in the Modoc Mining District, 32 miles north of Trona and 15 miles southeast of Darwin; elevation, 3500 ft. to 4000 ft.; owner *Hearst Estate*, San Francisco, California.

The property was discovered in 1875 and operated until 1890, during which period the production was $1,900,000. The orebodies worked occur along fissures in the limestone of the carboniferous age which has been intruded by diabase dikes.

The ore deposits occur along the bedding planes of the limestone where intersected by diabase dikes and sills. The general strike of the ore fissures is northwest and southeast. The ore mined is an argen-

tiferous galena and lead-carbonate, with gold and silver values; reported to carry ¼ oz. gold, 30% to 50% lead and from 50 oz. to 200 oz. silver. The dumps were worked by leasers, being treated in jigs, and concentrates produced are said to have carried 70 oz. to 160 oz. in silver, with 30% to 50% lead. (see Fig. 5)

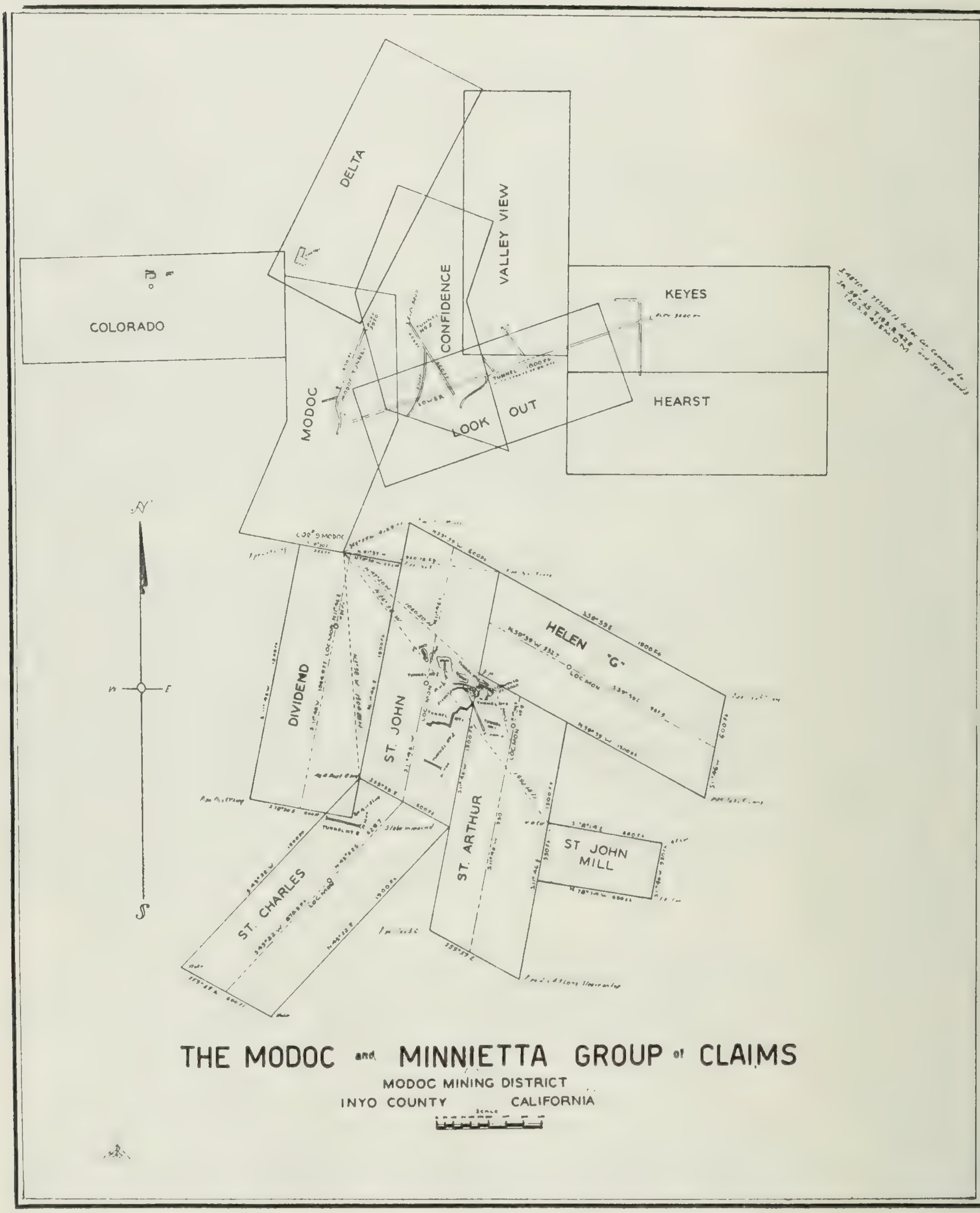


FIG. 9.

Development consists of a number of tunnels and shafts. At an elevation of 3240 ft. the lower tunnel has been driven southwest 1800 ft., with 2000 ft. of drifts. The tunnel is 1150 ft. in elevation below the vein outcrops. This tunnel is connected with Tunnel No. 2 by a raise 560 ft. between levels. At an elevation of 3800 ft., tunnel No. 2 is driven southeast 500 ft.; at 200 ft. southeast of portal, drift south

500 ft. There are about 1200 ft of crosscuts and drifts on this level. At an elevation of 3950 ft., the Modoc or No. 3 tunnel is driven 600 ft. south. The Modoc shaft is 600 ft. deep and there is an incline shaft 200 ft. The major portion of the tonnage mined was from No. 2 level, with a small amount from lower tunnel, indicating that the ore deposits bottomed about 100 ft. below the lower tunnel level. There is about 40,000 tons of ore on mine dumps, carrying 6% to 10% lead and 10 oz. to 15 oz. in silver.

Idle.

Bibl.: State Mineralogist's Reports XII, p. 24; XIII, p. 32; Report of Director of U. S. Mint, 1883 p. 164; 1884 p. 104.

Monster Mine (Blue Monster). It comprises 6 claims situated on the east slope of the Inyo Range of mountains and northwest of Saline Valley; owner, Dr. John MacLean, 2039 W. 68 St., Los Angeles.

The orebody occurs as an irregular lens of galena in a brecciated limestone. The trend of the ore-bearing fissure is northwest. Development consists of a tunnel driven N. 40° W. 275 ft. An open stope 200 ft. in length by 12 ft. in width extends from tunnel level to the surface.

The mine was operated by leasers in 1935, who shipped 50 tons of ore to U. S. Smelting, Refining and Mining Company's smelter at Midvale, Utah. Shipment was reported to carry $100 per ton in lead and silver.

Equipment consists of 1500-ft. jig-back tram to mill. Mill equipped with jigs.

Three men are employed on development work.

Bibl.: State Mineralogist's Reports XV, p. 101; XXII, p. 490; U. S. G. S. Bull. 540, p. 111; U. S. G. S. Professional Paper No. 110, pp. 117-118.

Montezuma Mine. It comprises 6 claims situated on the west slope of the Inyo Range, 10 miles southeast of Big Pine; elevation 4700 ft.; owner, Joseph Bros., Big Pine, Calif.; under lease to L. W. Sockman, Big Pine, Calif.

The country rock is limestone and slates which have been shattered and faulted. The ore forms in irregular lenses along a fault between limestone and clay slates. The ore is argentiferous galena, lead-carbonate, associated with sphalerite and zinc-carbonate, in a gangue of iron-oxide and decomposed lime. Ore shipped from the property carried 12% to 18% lead, 9% to 10% zinc and 10 oz. to 12 oz. in silver per ton.

Developed by three cross-cut tunnels driven northeast to intersect orebody at different elevations. Lower tunnel is 1400 ft. (caved), intermediate tunnel is 400 ft. and upper tunnel 200 ft. All ore has been worked out.

Idle.

Bibl.: State Mineralogist's Reports XIII, p. 32; XV, p. 102; XVII, p. 291; Reports of the Director of Mint, Precious Metals in U. S. 1883, p. 158; 1884, p. 100; U. S. G. S. Bull 540, pp. 109-110; U. S. G. S. Professional Paper No. 110, p. 116.

Noonday and Grant Mines are approximately 1½ miles southeast of the Gunsite Mine. They are also owned by the *Tecopa Consolidated Mining Co.*, which is controlled by Dr. L. D. Godshall, 722 South Oxford, Los Angeles.

An 8-mile railroad spur track connects the mine with the Tonopah and Tidewater at Tecopa.

The Grant adjoins the Noonday on the south and the outcrop of the fissure-filling is readily traceable between the two.

Shipments from the two properties have aggregated approximately 93,000 tons.

The Noonday produced 85,000 tons ranging in value from $10 to $75 per ton; average value of all shipments: gold, .091 oz.; silver, 7.29 oz.; lead, 15.39%.

PHOTO. 11. Noonday Mine, Tecopa Cons. Mining Co., Tecopa, Inyo County.

The Grant shipped 8000 tons with values from $8 to $50 per ton; average: gold, .064 oz.; silver, 5.87 oz.; lead, 11.05%.

The working of these mines are in the same fissure as those of the Gunsite Mine. The country rock is the Silver Rule dolomite. Here the vein strikes N. 40° W. and has an average dip of about 45° NE., although locally it flattens to 30° and, in places, may dip as steeply as 60°.

The main orebodies occur along a series of N.-S. fractures in the dolomite. In places the width may be 30 ft. or more. A series of N.-S., steeply dipping to vertical faults have probably influenced the position of the shoots in the vein. Two principal ore-shoots have been mined; one at the main shaft, the other at the winze. These may, in places, consist of a series of overlapping lenses, but the zone of the occurrences is more or less continuous within the shoots. The ore consists largely of lead-carbonates with some unoxidized galena.

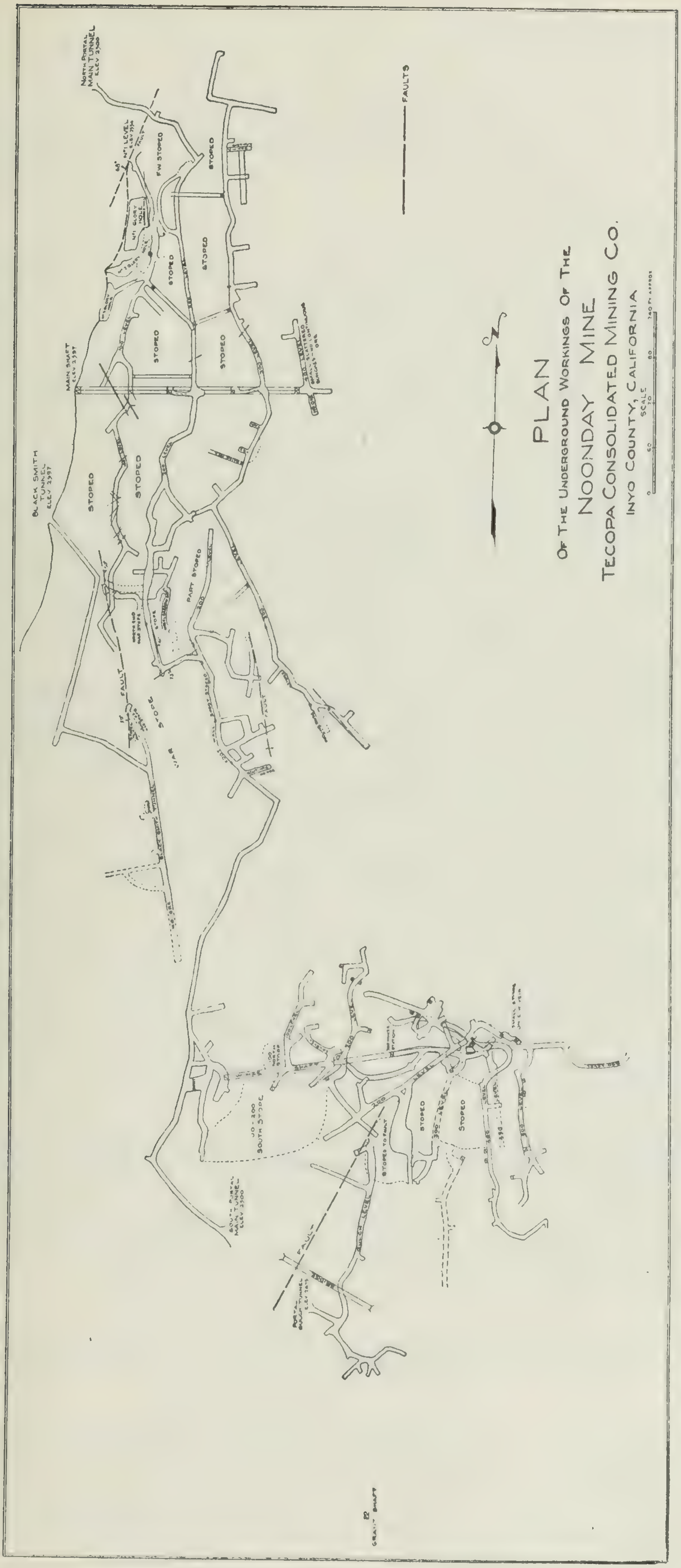

PLAN
Of The Underground Workings Of The
Noonday Mine
Tecopa Consolidated Mining Co.
Inyo County, California
Faults

FIG. 10.

The development, consisting of a shaft to the 400-ft. level and a 600-ft. winze below the tunnel, is shown on the accompanying map. (Fig. 10.)

Equipment consists of gasoline hoists at the shaft and winze of the Noonday. A 25-hp. gas engine operates a 2-drill compressor at the south portal of the tunnel. The Grant shaft is equipped with a 35-hp. gasoline hoist.

Idle at present.

Bibl.: State Mineralogist's Reports XV, pp. 103-104; XVII, pp. 291-293; XXII, pp. 491-492.

Ophir Mine. It comprises 15 claims, 2 patented and 13 unpatented, situated on the west slope of the Slate Range of mountains, 10 miles northeast of Trona; owner, *Engineers Exploration Company;* W. A. Coons, president; Edith Coons, secretary; C. O. Mittendorf, manager, California Reserve Bldg., Los Angeles, California.

The orebody consists of a fissure in limestone which strikes N. 30° with a dip of 60° to 70° W. which has been developed along its strike for over 1000 ft. Width of orebodies developed along the fissures varies from 2 ft. to 20 ft.. The ore is galena and lead-carbonate, and lead-vanadate. The ore shipped from the property carries 30% lead, 3% zinc, 20% iron and from 5 oz. to 7 oz. in silver.

The company operated the property from 1926 to March 1, 1930, when operations were suspended due to a drop in metal prices. In 1929 a 100-ton concentration plant was installed on the property which operated from Nov. 1, 1929, to March 1, 1930.

Mill: 300-ton coarse ore bin, Wheeling jaw crusher, 2-in. Symonds disc cone crusher, 100-ton fine ore bin, Hardinge rod-mill in closed circuit with Duplex Dorr classifier; Dorr bowl type of classifier, 2 Wilfley sand tables and 4 Wilfley slime tables. Mill is driven by electric motors; total hp., 130. Electric power is secured from the Southern Sierras Power Company.

The mine was reopened and operated under lease to C. O. Mittendorf in June, 1936, to September 1, 1937, who shipped 400 tons of ore to Selby Smelting Co., with an average grade of 40% lead and 7 oz. in silver per ton.

Development consists of three shafts, the main vertical shaft being 500 ft. Deep underground workings consist of 2500 ft. of drifts and cross-cuts.

Mine equipment consists of 50-hp., double drum, electric-driven hoist 300 cu. ft. Ingersoll-Rand compressor. The property is reported to have produced $500,000.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 105; XXII, pp. 492-493.

Paddy Pride Mine. It comprises 5 claims, situated at the southern end of the Amargosa Range of mountains, 9 miles west of Zabriskie, a station on the Tonopah & Tidewater Railroad; elevation, 3500 ft.; owner, Paddy Pride Silver Mining Company; John T. Overburg, president, Shoshone, California.

The ore occurs as irregular, lenticular deposits of carbonate of lead in limestone. The general trend of the fissure is northwest, dip 60° to 70° SW. The vein varies in width from 4 ft. to 8 ft.

Development consists of two tunnels, one 150 ft. in length, the other 200 ft.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 294; XXII, pp. 493-494.

Panamint Mines (silver). This property comprises 11 patented claims and 7 claims held by location, situated in the Panamint Mining District, in Surprise Canyon, on the west slope of the Panamint Range, 10 miles northeast of Ballarat; elevation, 6000 to 7500 ft.; owner, A. D. Myers, Los Angeles, California.

The vein system comprises a series of parallel quartz veins in schist and limestone; strike NW.-SE., dip 60° to 70° NW. Widths vary from 6 to 8 ft. The vein quartz is mineralized with tetrahedrite and stained with bromides of silver, azurite, and malachite.

Development consists of tunnels, the main cross-cut tunnel being 2300 ft. in length. Property has been idle since June, 1926.

Bibl.: State Mineralogist's Reports XVII, pp. 280-281; XXII, pp. 495-500; XXVIII, pp. 361-364.

Pennsylvania Mine. It is situated in the Swansea District at the old camp of Swansea, 3½ miles northwest of Keeler; elevation, 4000 ft.; owner, J. D. Leary, Lone Pine, California.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 293; XXII, p. 495.

Pete Smith Mine. It comprises 6 claims, situated on the west slope of Inyo Range of mountains, 4½ miles east of Keeler; elevation, 4850 ft.; owners, Paul Watterson and William Skinner, Lone Pine, California.

Bibl.: State Mineralogist's Report XXII, pp. 495-496.

Pierson Mining Company's Group of Mines. It comprises 20 claims situated on the west flank of the Inyo Range, 7 miles east of Independence and 3 miles northeast of Kearsarge; elevation, 4450 ft.; owner, R. B. Whiteside, of Duluth, Minnesota.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 496.

Promontory Mine. It is situated in the Darwin District, 1½ miles south of Darwin; elevation, 5000 ft.

Idle.

Bibl.: State Mineralogist's Reports XV, pp. 105-106; XXII, p. 496.

Raven Mine (lead-silver). It comprises 6 claims, situated in the Ubehebe District, 5 miles north of Dodds Springs, and 70 miles northwest of Death Valley Junction; elevation, 3800 ft.; owner, Archie Farrington Estate, Bishop, California.

Redwing Mine. It is situated in Resting Springs District, 4 miles northeast of Shoshone, on the west slope of Resting Springs Mountains; owner, R. J. Fairbanks, of Shoshone, California. Idle.

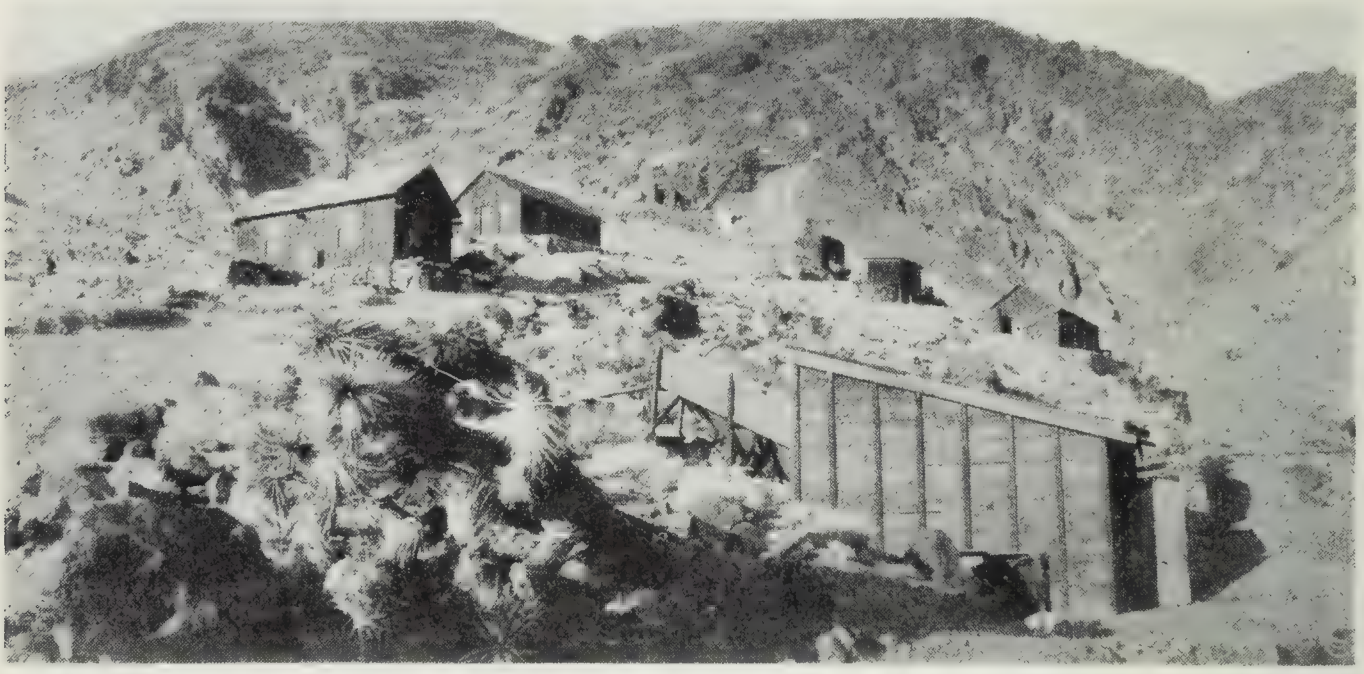


PHOTO. 12. Santa Rosa Mine on east slope of Inyo Range. Photo by J. R. LeCyr, Keeler, California.

Reed Flat Mine. It comprises 8 claims and millsite claim at Black Canyon Spring, situated on the western slope of the White Mountains, two miles south of Reed Flat and 16 miles by road via Black Canyon east of Bishop; owners, Judge J. O. Ray, Beatty, Nevada, and Fred Smith, of Bishop.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 497.

Royal Mine. See Cerro Gordo Extension Mine.

Sam Lucas Mine. It comprises 7 claims situated in the Cerro Gordo District, on the west slope of the Inyo Range, two miles east of Cerro Gordo Mine, and 9 miles east of Keeler; elevation, 7500 ft.

Idle.

San Pedro Mine. It comprises 2 claims, situated on the east slope of the White Mountains, 16 miles southeast of Big Pine; elevation, 7700 ft.; owner, W. A. Coulter, San Pedro, California.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 498.

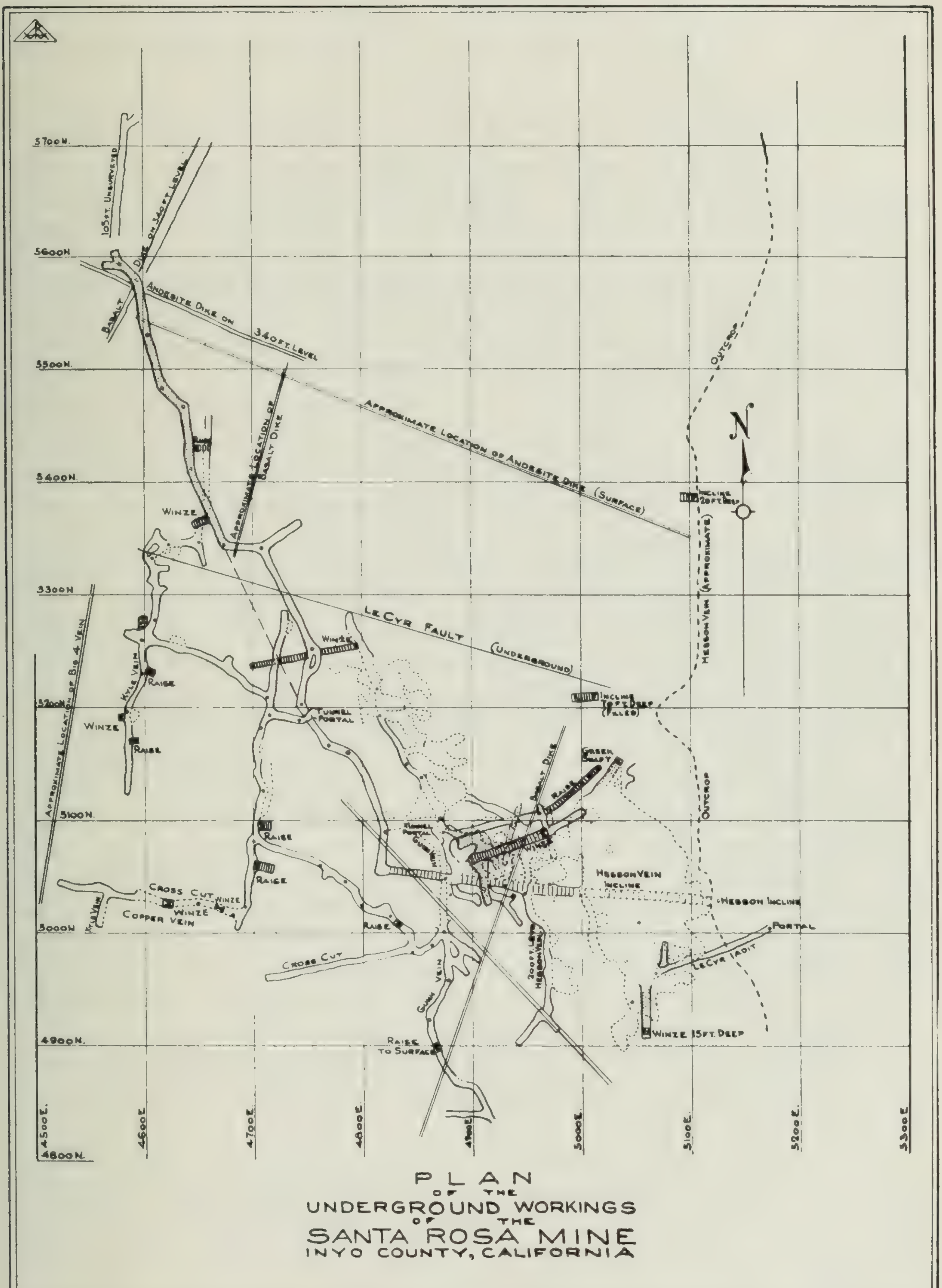
Santa Ana Mine. It comprises 3 claims, situated in the Darwin District in the Argus Range, $1\frac{1}{2}$ miles east of Darwin; elevation, 4450 ft.; owner, Alex Rouna, Darwin, California.

The mine is on the ridge north of Lone Canyon, here a fissure in the limestone strikes N. 40° E. with a width of 6 to 8 ft. The ore occurs as lenses of galena and lead carbonate. Development consists of shaft 200 ft. deep with levels at 75, 150, and 200 ft.

Idle.

Santa Rosa Mine (lead-silver). It comprises 6 contiguous patented claims totaling 113 acres and one millsite, situated in the Lee

Mining District, on the east slope of the Inyo Range, 26 miles by road east of Keeler; elevation, 6500 ft to 7000 ft.; owner, Santa Rosa Mining Company; J. R. LeCyr, president, 310 Black Bldg., Los



PLAN OF THE UNDERGROUND WORKINGS OF THE SANTA ROSA MINE INYO COUNTY, CALIFORNIA

FIG. 11.

Angeles, California; Lessee, Santa Rosa Mines Development Company; operating through receivership; C. W. Dow, of Lone Pine, Trustee. Two sets of leasers have operated the property since 1935, R. E. Mac-

Donald and C. Grand, of Keeler, and John McPherson and Walter Uttich, of Keeler. The ore shipped by the leasers amounted to 1500 tons; reported to average 16.62% lead and 15.35 oz. in silver per ton. The production of the property from 1915 to 1931 was 20,735 tons with an average assay value of 0.015 oz. gold, 17.28 oz. silver, 1.69% copper and 22.74% lead. The total production of the property has been about $1,000,000.

GENERAL GEOLOGY

The formation in which the orebodies occur consists of a series of partly metamorphic, thin-bedded quartzites, argillites and limestone of Pennsylvanian age, which strikes northerly and southerly, dip easterly at angles varying from 40° to 70°. The individual beds are from 1 ft. to 5 ft. in thickness. These formations are exposed for only about 500 ft. vertically and not more than 2000 ft. on the strike, being completely surrounded by post-mineral basalt tuffs and flows of late Tertiary age.

A post-mineral fault has dropped all formations to the east a distance of 500 ft. to 1000 ft. The sediments and orebodies are cut by three post-mineral dikes; two of basalt and the other of andesite. The orebodies are of the fissure-vein type and occur in a dozen or more closely spaced veins, from 25 ft. to 100 ft. apart, which strike N. 17° W. and dip from 30° to 70° W. These fissures are cut by a few small, easterly-westerly fissures which are also mineralized in places.

The orebodies consist of replacement of the walls along fissures together with more or less irregular impregnations of the adjoining rock, by pyrite, galena, sphalerite and chalcopyrite. With the exception of some of the galena, these minerals are now all oxidized.

Development: The Hesson vein which is the largest and most productive is developed by a single-compartment incline shaft 340 ft. in depth which follows the Hesson vein orebody on its dip of about 35°. The lower 70 ft. of the shaft, flattens to 17°, leaving the vein. Drifts have been driven on the vein on the 200-ft. level, 270-ft. level and 340-ft. level. The main production of ore mined has so far been from the Harper and Hesson veins. On the 270-ft. level, about 40 ft. north of the shaft, a crosscut has been driven east 170 ft. cutting a mineralized fissure. At this point there is a raise up 100 ft. and a winze has been sunk on the fissure to a depth of 165 ft. in the ore. On the 340-ft. level, drift north 960 ft. on the Harper vein. The other veins are developed by tunnels and shallow shafts and surface cuts. (See Fig. 11.)

Mine equipment consists of 60-hp. semi-Diesel engine 18-hp. Western gas engine hoist one 350-cu. ft. Gardner-Denver compressor driven by the 60-hp. semi-Diesel engine, Ingersoll-Rand tugger hoist, jack hammers and stopers, together with various other underground equipment.

Six men are employed.

Bibl.: State Mineralogist's Reports XV, p. 107; XVII, p. 294; XXII, p. 498.

Silver Button & Shamrock Mines. See Darwin Keystone Mines.

Silver King Mine. It is situated in Sec. 8, T. 24 S., R. 43 E., M. D. B. & M. on the west slope of the Slate range, 9 miles north of Trona; elevation, 3600 ft.

Bibl.: State Mineralogist's Report XXII, p. 500.

Silver Peak Mine (Hemlock). See Panamint Mines.

Silver Reef Mine. It is situated in the South Park District, 6 miles east of Ballarat, near the summit of the Panamint Range.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 108; XVII, p. 294; XXII, p. 500.

Silver Rule Mine. It comprises 12 claims situated in Resting Springs District, on the southwest slope of the Kingston Range, 17 miles east of Morrison's siding, on the Tonopah and Tidewater Railroad; owner, *Pacific Lead & Silver Mining Company;* A. J. Jarmuth, president, Los Angeles, California.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 104; XVII, pp. 365-366; XXII, p. 500.

Silver Spoon Mine. It comprises 5 claims, situated in the Darwin District, on the west slope of the Argus Range, 2 miles southeast of Darwin; owner, Theodore Peterson, Darwin, California.

The ore occurs along a fissure in limestone which strikes N. 30° W., dip 40° W. Width of the vein varies from 3 ft. to 6 ft. The ore is galena and lead-carbonate, carrying values in silver. Ore shipments show a value of 20% to 30% lead with 15 oz. to 25 oz. in silver per ton, also a small amount of gold.

Development consists of a shaft sunk on an inclination of 75° to a depth of 250 ft. with levels at 150 ft. and 250 ft. On the 150-ft. level, a drift has been driven west 150 ft. in ore. On the 250-ft. level, a crosscut has been driven south 100 ft. to a vein that strikes E.-W. and dips 75° S.; width, 2 to 8 ft.; drift on fissure, 125 ft. west. The vein material is iron-stained, carrying bunches of galena and lead-carbonate. Ore mined is reported to carry 38% lead with 25 oz. in silver per ton.

Mine equipment consists of a 6-hp. gas engine hoist.

Two men are employed.

Bibl.: State Mineralogist's Report XXII, pp. 500-501.

Slate Range Mine. (See California Queen or Gold Bottom Mine.)

Standard Group of Mines. It comprises 11 claims, situated in the Darwin District north of Lane Canyon, in the Argus Range, 4 miles by road east of Darwin; owner, Alex Rouna, Darwin, California.

A series of fissure veins in lime-silicate rock strikes northwest. Width varies from 40 ft. to 50 ft. The ore occurs as lenses of galena and lead-carbonate with widths ranging from 2 ft. to 6 ft. Developments consist of tunnels and opencuts.

Mine equipment consists of two Ingersoll-Rand portable compressors.

Two men are employed.

Sterling Mine (silver). The property comprises 6 claims situated in T. 20 S., R. 42 E., M. D. B. & M., in Revenue Canyon, on the slope of the Argus Range of mountains, 28 miles north of Trona; elevation, 3000 ft.; owner, Sterling Mining Company; James Stevenson, president, Trona, California.

A quartz vein, 4 ft. to 6 ft. wide, occurs on contact of quartz monzonite and limestone. The vein quartz is mineralized with argentite and bromide of silver; said to carry from $8 to $15 per ton in silver. The vein strikes N. 10° E., dips 60° E.

Development consists of a shaft sunk on the vein to a depth of 285 ft. On the 150-ft. level, a drift has been driven 50 ft. south in ore. On the 280-ft. level, drift south 20 ft. About 50 ft. south is another shaft 120 ft. in depth sunk on the vein with stopes each side of the shaft. Ore mined goes to jig-back tram with a length of 1500 ft. to a 35-ton ore bin located in the canyon 500 ft. in elevation below the mine. From the ore bin, ore is delivered to a No. 2 Wheeling crusher, then to a 4 ft. by 4 ft. Kohler ball mill; in closed circuit with Dorr Duplex classifier, then to 2 Wilfley concentrators and 3 Groch flotation cells. Concentrates produced were reported to be 2.5 oz. in gold, with 300 oz. in silver per ton, the ratio of concentration being 60 to 1. A 75-hp. semi-diesel gas engine drives the mill. Water to operate the mill comes from a spring in Revenue Canyon, a distance of one mile through 1½-in. pipe line to a storage tank having a capacity of 10,000 gallons.

Mine equipment consists of a 6-hp. hoist and 310-cu. ft. National compressor.

Fifteen men are employed.

Swansea Mine (lead-silver). It is situated in the Swansea Mining District, on the west flank of the Inyo Range, 2½ miles north of Keeler; elevation, 4550 ft.; owner, W. F. Whiteside, Duluth, Minnesota.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 501.

Swansea Chief Mine. It is situated in the Swansea Mining District, on the southwest slope of the Inyo Range, 4 miles northeast of Keeler; elevation, 4600 ft.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 294; XXII, p. 501.

Ubehebe Mine. It comprises 12 claims situated in the Ubehebe Mining District, in the Ubehebe Range, 50 miles northwest of Furnace Creek Ranch; elevation 3930 ft.; owner, *Archie Farrington Estate*, Bishop, California; under lease to Grant Snyder, Salt Lake City, Utah, and C. A. Rankin, Los Angeles, California.

The deposit is an irregular replacement in limestone, varying up to 15 ft. in width. The limestone is cut by intrusions of diorite dikes. The ore consists principally of oxidized ores of lead-carbonate and lead-sulphate with occasional bunches of galena.

Development consists of tunnels and open-cuts. Ore is hauled by truck to Death Valley Junction. Shipments are reported to carry from 50% to 60% lead with silver values.

Ten men are employed.

Union Mine (Mount Whitney-Union, Big Wedge, Monte Carlo) (lead-silver-gold). The property comprises 7 claims situated in the Russ Mining District, in Sec. 14, T. 14 S., R. 36 E., M. D. M., on the west slope of the Inyo Range, 3 miles northwest of Owenyo, a station on the Southern Pacific Railroad; elevation, 5500 ft.; owner, *Monte Carlo Mines, Inc.;* A. J. Israel, president, Los Angeles.

The property was operated by the *Mt. Whitney-Union Mining Company* from 1926 to 1928; then by *Hollinger Mines Company,* Ontario, Canada, from 1928 to 1929; in August, 1934, by the *Big Wedge Mining Company;* E. J. Harrison, president, until August, 1935. This company became involved in financial difficulties and a receiver was appointed by the Federal Court of Los Angeles.

In February, 1936, at a receivership sale the property was purchased by A. J. Israel, of Los Angeles, who formed the Monte Carlo Mines Company and operated the mill on ore from the Brown Monster and Reward Mines from March, 1936, to August, 1936, when operations were suspended due to unsatisfactory recovery made by flotation on the gold-silver ores of the Reward Mine. No work was done by the Monte Carlo Mines Company on the Union Mine. In 1928 the Hollinger Mines Company drove No. 4 tunnel 700 ft. east in the hanging wall of the Union vein, and then a crosscut was driven 100 ft. north on the assumption that the vein was faulted to the north. If the crosscut had been run south they would have intersected the vein. The Big Wedge Mining Company put up an incline raise 50 ft. east of the portal of the tunnel intersecting the vein, and is then driven on the vein for a distance of 200 ft. At the top of the raise a tunnel was driven on the vein a distance of 100 ft. The ore developed in these workings was treated in the mill. The Union vein is a massive quartz vein which cuts across thin-bedded limestones and calcareous slates. The vein strikes N. 70° E., dip 60° to 65° W. Width varies from 6 ft. to 20 ft. The vein quartz is mineralized with galena and lead-carbonate and carries values in gold and silver. The vein has been developed by eight tunnels at different elevations. These tunnels vary from 400 ft. to 700 ft. in length. Total amount of underground workings is about 3000 ft. The mill is a flotation plant having a capacity of 150 tons per day. The equipment comprises 10 in. by 20 in. Wheeling crusher, 150-ton fine ore bin, 6 ft. by 22 in. Hardinge ball mill in closed circuit with 6 ft. by 22 ft. Dorr Duplex classifier, 4 ft. by 8 ft. Marathon Rod mill (in open circuit), 6 ft by 6 ft. conditioner tank, 2-12 ft. Southwestern Engineering Company's Airfloat rougher cells, one 8 ft. Southwestern Engineering Company's Airfloat cleaner cell, one 3 ft. by 6 ft. cone thickener, one 3 ft. by 6 ft. American 2-leaf filter. All the equipment was recently purchased by the Mine and Mill Machinery Company, of Los Angeles.

Mine equipment consists of Ingersoll-Rand compressor; capacity, 750 cu. ft.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 84; XXII, pp. 501-502.

Utacala Mine (zinc). It comprises 12 claims situated in the Darwin District, on Zinc Hill, in the Argus Range, 9 miles east of Darwin; elevation, 4000 ft.; owner, Albert Miller, of Keeler, California.

The country rock is limestone and quartz monzonite. The ore is deposited as zinc-carbonate and sphalerite along fissures in the limestone. These fissures strike N. 30° W. The width of the ore mined was from 4 ft. to 8 ft. Development consists of five tunnels, from 100 ft. to 600 ft. in length.

Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 294-295; XXII, p. 503.

Ventura Mine (Silver Reef). It comprises 16 claims, one patented and 15 unpatented, adjoining the Ignacio Mine on the north, on the west slope of the Inyo Range of Mountains, 7 miles east of Keeler; elevation, 7300 ft.; owner, Mrs. Charles Baagoe, Keeler, California.

Two well-defined veins occur in limestone; one vein strikes N. 30° W., and dips 70° to 80° W., the other strikes N. 20° E., and dips 80° E.; widths of veins vary from 2 ft. to 5 ft. These two veins intersect on the ridge north of the Ventura shaft, and to the west of this intersection is an intrusion of quartz-monzonite. This intrusion has effected a large amount of contact metamorphism and converted an extensive body of carboniferous limestones into garnet and other dense fine-grained, lime-silicate rocks. The ore occurs as irregular lenses of galena and lead-carbonate in fissures in the lime-silicate rocks. Shipments of ore carry 12 oz. silver per ton, 30% to 33% lead and 1% to 2% of zinc.

Developments consist of a shaft 150 ft. deep and four tunnels, 100 ft. to 400 ft. in length. The lower tunnel is driven northeast 400 ft. Reported production of the property is $100,000.

Idle.

Bibl.: State Mineralogist's Reports XV, p. 110; XVII, p. 295; XXII, p. 503; U. S. G. S. Professional Paper 110, p. 117.

War Eagle Mine. It comprises 9 patented claims situated in Sec. 14, 15, 22, 23, T. 20 N., R. 8 E., S. B. M., in the Resting Springs District on the western slope of the Nopah Range, 9 miles southeast of Tecopa and one mile south of the Grant Mine; elevation, 2600 ft.; owner, *Tecopa Cons. Mining Company;* Dr. L. D. Godshall, general manager, Los Angeles, Calif.

The deposit is a continuation of the Gunsite-Noonday vein. The ore is lead-carbonate, with some unoxidized galena and carrying values in gold of 0.50 oz. per ton. Developments consist of a crosscut tunnel driven N. 60° E., 450 ft. to the vein, with drift south 450 ft. on the vein; also winze sunk on the vein 100 ft. below the tunnel level.

Idle.

Bibl.: State Mineralogist's Report XXII, pp. 503-504.

Westgard Mine (Chalmers) (lead-silver). It comprises 14 claims, situated in the Deep Springs Mining District, on the eastern slope of the Inyo Range, near Antelope Springs, about 16 miles northeast of Big Pine; elevation, 6000 ft.; owner, Westgard Consolidated Mining Com-

pany; Mark G. Bradshaw, president; C. K. Loring, secretary, Tonopah, Nevada.

The ore is galena and lead-carbonate that occurs on contact between limestone and quartz-diorite. The fissure strikes northwest and dips 45° southwest. The orebody is from 2 ft. to 6 ft. wide. Developments consist of two shafts, one 100 ft. deep with 250 ft. of drifts, and two tunnels, 100 ft. and 200 ft. in length, respectively.

Idle.

Bibl.: State Mineralogist's Reports XVII, p. 284; XXII, p. 482.

Wonder Mine. It comprises 4 claims situated in the Darwin District, in the Argus Range, 1½ miles east of Darwin; elevation, 4700 ft.; owner, Richard Wallace, Darwin, California.

The ore occurs as irregular lenses of galena and lead-carbonate along a fissure in the limestone that strikes northwest and dips 45° W. The vein-filling is a coarse calcite with some crystalline fluorite. Development consists of two incline shafts, one 225 feet deep, the other 100 feet deep.

Idle.

Bibl.: State Mineralogist's Report XXII, p. 504.

MOLYBDENUM

Deposits of molybdenite, the sulphide, occur in a number of localities in Inyo County. Wulfenite, lead-molybdate, occurs, associated with lead ores in the Slate Range, especially at the Ophir Mine. Crystals of wulfenite occur with linarite and caledonite in the Cerro Gordo Mine. It is also reported to occur in mines of the Darwin District with crocoite. Molybdenite occurs scattered through a quartz vein along a contact on the east slope of the Inyo Range, 7 miles east of Kearsarge, also in the Pine Creek Tungsten Mine in commercial quantities, associated with scheelite. It is reported that in certain sections of the mine an orebody has been developed which has a thickness of 30 ft. and is said to have an average value of 1% to 2% MoS_2. A recent discovery of molybdenite disseminated in a granite formation has been made north of Hamilton Canyon on the west slope of the Coso Range that may prove of commercial importance.

Coso Molybdenite Mine. It comprises two groups of claims known as the Desoto Group and the Molybdenite Group, each consisting of 6 claims, totaling 240 acres, situated in T. 20 S., R. 38 E., in the Coso Mining District, north of Hamilton Canyon in the Coso Range, 12 miles by road southeast of Olancha; elevation, 6000 ft.; owners, H. A. Clark and John Stuart, of Darwin, locators of the Desoto Group, and Lacy Harper, of Olancha, of the Molybdenite Group; under lease and bond to J. Frank Reeves, 5514 Wilshire Blvd., Los Angeles. The molybdenite occurs disseminated in a granite stock, in seams and joints of the rock which has been shattered by folding. The mineralized area is about 400 ft. wide and 900 ft. in length. The development consists of two tunnels and a number of open cuts. Samples taken from different points along the outcrop are reported to carry from 0.08% to .65% MoS_2, with a general average of .35% MoS_2.

Mine equipment consists of a Gardner-Rix portable compressor.

Five men are employed on development work.

Pine Creek Tungsten Mine. It comprises 12 claims and a millsite, situated on the south slope of Mount Morgan, in the Sierra Nevada Range, 45 miles by road northwest of Bishop; elevation, 10,500 ft.; owner, *United States Vanadium Corporation;* R. J. Hoffman, presi-

PHOTO. 13. View of Trenches on Coso Quicksilver Deposit, Coso Hot Springs, Inyo County.

dent; J. R. Van Fleet, vice president and manager; B. G. Smith, secretary; Clarence H. Hall, Supt.; offices, 30 E. 42d Street, New York; local office, Richfield Building, Los Angeles.

It is a contact metamorphic deposit between dolomite and granite, carrying values in scheelite and molybdenite, traceable for over 4000 ft., with a width of 50 ft. and proved to a depth of 900 ft. The molybdenite ore occurs on contact of granite and the tungsten orebody, striking N. 50° E., dip vertical. A highgrade stringer of molybdenite ore, 6 in. to 8 in. wide, occurs on the hanging-wall granite, and the molybdenite is also disseminated in the footwall rock for a thickness of 10 ft. to 30 ft. The rich stringer runs as high as 90% molybdenite. For a description of the mine and mill, see under Tungsten. The company plans to treat the ore in a 300-ton concentration plant, at present operating on tungsten ore from the mine.

QUICKSILVER

Coso Quicksilver Deposit. It comprises 1000 acres, situated in Secs. 7, 8 and 16, T. 22 S., R. 38 E., M. D. M., in the Coso Range, 2½ miles southwest of Coso Hot Springs, and 11 miles east of Coso Junction, a siding on the Southern Pacific Railroad; elevation, 3635 to 4300 ft.; owner, F. J. Sanders, 1434 Garden St., Santa Barbara, California; under lease and bond to A. W. Leege, Santa Barbara, California.

The discovery of mercury in Devil's Kitchen Canyon near Coso Hot Springs was made by F. J. Sanders some time in 1929 and since that date a considerable amount of trenching and surface cuts have exposed a large area mineralized with mercury. The principal mineralization is confined to rhyolite which overlies granitic rocks in Devil's Kitchen Canyon and on the hill south of the canyon. The mineralized area in the Devil's Kitchen Canyon is 1200 ft. in length, about 600 ft. in width and about 300 ft. thick. In places the orebody is covered with unaltered rhyolite in thickness from 2 ft. to 20 ft. Samples taken from this orebody are reported to range from 0.16% Hg to 6% Hg. Samples of selected ore carried from 7% to 11% Hg. The second area of enrichment is located one-half mile northeast of Devil's Kitchen, and embraces about 40 acres, known as the Nicol property. The major portion of development has been confined to this property. This development consists of 4 trenches about 8 ft. deep, 6 ft. wide and from 200 ft. to 400 ft. in length, in north and south direction. These cuts are about 250 ft. apart. There are also a number of shallow shafts, 10 ft. to 40 ft. in depth. Samples cut at 5-ft. intervals in the above-mentioned cuts are reported to give an average assay value of 7 lb. to 8 lb. of mercury per ton of ore. In 1935 a 12-pipe Johnson-McKay retort was installed which had a capacity of one ton of ore per 24 hours. The retort was

PHOTO. 14. 20-ton Herreschoff Multiple-Hearth Furnace at Coso Quicksilver Mine, Coso, Inyo County.

operated on selected ore mined from cuts and during 7 months of operation produced 7296 lb. of mercury, or 96 flasks.

Early in 1938 a Herreschoff furnace, Cottrell dust-precipitation and condenser plant, having a capacity of 25 tons per day, were installed. A small power shovel was installed in the Devil's Kitchen

area and most of the ore at present (May, 1938) comes from there. A recovery of 8 lb. to 10 lb. of quicksilver per ton is reported.

Nine men are employed.

Bibl.: State Mineralogist's Report XXVI, pp. 58-63.

TUNGSTEN

Tungsten ores occur in Inyo County as scheelite (calcium tungstate) in the Tungsten Hills west of Bishop, Round Valley, in the low foothills 3 miles south of Bishop, Deep Springs Valley, Ubehebe District, and in the Pine Creek area of the Sierra Nevada.

In the past, commercial production has been confined to those deposits on the west side of Owens Valley. These occur in the Sierra Nevada and its foothills. They have been found in an area which is some 20 miles long and constitutes one of the few known localities of the world where scheelite occurs in commercial quantities in contact-metamorphic deposits. The orebodies are found in limestone at its contact with the granitic rocks which form the core of the main mountain range. The bodies of limestone are remnants of the original deposition and are now found largely as roof pendants, projecting into the granitic rocks to varying depths.

The deposits were discovered in 1913 [1] but were not developed until the spring of 1916. They were operated until 1920 and shut down on account of low prices. In 1924 the Tungsten Products Company started operations in Pine Creek, which continued until 1929. Recent increase in the price of tungsten has so stimulated interest that there were in April, 1938, four mills operating in the county, with a combined capacity of approximately 450 tons per day.

Adamson Tungsten Deposit, comprising 8 claims, is in the Pine Creek District, on Morgan Creek. It adjoins the Pine Creek Mine on the north and is approximately 21 miles (air line) west of Bishop; elevation about 11,000 ft.; owner, D. B. Adamson, Bishop, California; under lease to W. B. Lenhart and Charles F. Johnston, Bishop, Calif.

It is reported that a vein carrying one per cent scheelite has been traced by means of trenches for a distance of 2500 ft.. Its width varies from 4 ft. to 30 ft. Fifteen hundred feet east of this vein there are two parallel outcrops, approximately 20 ft. in width, reported to carry 2% WO_3. Another outcrop 25 ft. in width, for a length of 225 ft., reportedly carries one to $1\frac{1}{2}$% WO_3.

It is understood that the lessees are now preparing to develop the property.

Bishop Tungsten Company: A. T. Wilkerson and Ralph H. Moore, of Bishop, have under lease and option 28 acres of patented land and 4 mining claims in the low granite foothills, 4 miles south of Bishop on the west side of Owens Valley; elevation, about 4500 ft.; owner, Joseph Rossi, Bishop, California.

Scheelite occurs in limestone along its contact with the granitic country rock; the strike is NE.-SW. The mineral-bearing zone has been exposed, in places, across a width of 20 ft. or more. The associ-

[1] U. S. G. S. Bulletin 640-L, p. 249.

ate minerals are garnet and magnetite, with subordinate amounts of epidote and quartz.

Development consists of a 60-ft. tunnel and a series of open cuts. The ore from above the portal of the tunnel has been removed and sent to the mill. This open cut is about 12 ft. wide, 30 ft. long and 20 ft. high. It is reported that approximately 20 lb. of scheelite is recovered per ton of ore treated.

The mill, which is 3 miles southeast of the mine and ½ mile west of the highway, consists of the following: 40-ton coarse-ore bin, 8 by 8

PHOTO. 15. 50-ton Mill—Rossi Tungsten Mine, Bishop Tungsten Company, Bishop, Inyo County.

jaw crusher, elevator to 50-ton fine-ore bin, to 12-mesh vibrating screen, oversize to 3 by 3 low-discharge ball mill, product and screenings to 2 Overstrom tables, in series; concentrates to an electric dryer and a Stolle electrostatic separator. A 70% to 72% concentrate is made. At the time of visit (Nov., 1937), the plant had been running only a few days, so that the percentage of extraction had not been definitely determined. Capacity is about 30 tons daily. Seven men are employed.

Crawford deposit, consisting of 4 claims, is on Mount Tom, 2 miles south of Big Pine Creek; elevation, 10,000 ft.; owner, Cord Crawford, Bishop, California.

It is reported that this deposit, which is undeveloped, carries from 2% to 5% WO_3 across considerable widths.

Idle.

El Diablo Mining Company: H. O. Johanson, secretary, Bishop, has subleased 8 claims at Tungsten City from the Tungsten City Milling Company. The property is 8 miles west of Bishop in the Tungsten Hills and was formerly known as the *Aeroplane Group;* elevation, about 5500 ft.; owner, J. V. Baldwin, Los Angeles.

The orebody occurs in limestone at its contact with the inclosing quartz-diorite. This limestone pendant trends N.-S. and stands practically vertical. The ore is scheelite occurring in a gangue consisting of garnet and epidote, principally, with subordinate amounts of quartz. The ore occurs as lenticular masses from 50 ft. to 80 ft. long and 10 ft. to 20 ft. wide.

Development consists of a cross-cut tunnel driven west about 700 ft. with several hundred feet of drifts in the ore-bearing zone. Considerable stoping has been done above these drifts, and raises from the tops of these stopes connect with the bottom of a large glory hole which is some 150 ft. above the cross cut. The glory hole is approximately 200 ft. long by 200 ft. wide by 200 ft. high (at the highest point). The present operators are raising on good ore out of the top of one of these stopes. They have milled considerable low-grade material out of the old chutes.

The mill, which is located near the Bishop Creek road, some 3 miles west of Bishop, consists of the following: 50-ton bin, 9 by 14 jaw crusher, elevator, 18 in. Symons disc crusher, 18 in. by 36 in. rolls, 12-mesh vibrating screen, oversize elevator return to rolls, screenings to 2 Overstrom tables. A 30% concentrate from the tables is cleaned to 70%-72% by a Stolle electrostatic separator. Capacity is about 40 tons per day. Six men are employed.

Bibl.: (*Standard Tungsten Mine*) State Mineralogist's Reports XV, pp. 129-130; XVII, p. 303; XXII, p. 512; (*Aeroplane Group*) U. S. G. S. Bull. 640L, pp. 243-245.

Emergency Group of 8 claims is on the ridge east of Beer Creek at its mouth, in Deep Springs Valley, 22 miles northeast of Big Pine and 6 miles west of Deep Springs School; owners, Harry Brown and Frank Bedell, of Big Pine, California.

In the limestone at its contact with the granite, scheelite occurs in a lode which strikes N.-S. and dips 70° W. The width of the mineralized belt is 50 ft. It is traceable for a length of 4500 ft. It is reported that the ore runs 0.5 to 1% WO_3.

Idle.

Feldman Tungsten Mine. It comprises 5 claims located in T. 23 S., R. 38 E., M. D. M., in south end of the Coso Range, 2 miles east of Little Lake; elevation 3500 to 4000 ft.; owner, Frank Feldman, Independence, California; under lease and bond to E. E. Brown, Los Angeles, California.

This deposit of scheelite in a quartz vein was discovered in January, 1937, by Frank Feldman, and some high-grade ore sorted out reported to carry 60% WO_3.

A vein of quartz 2 ft. to 4 ft. wide occurs in granite, and can be traced along its outcrop for a distance of 2800 ft.

The quartz is mineralized with scheelite crystals which are white to orange in color. The vein quartz is reported to carry from 1% to 5% WO_3.

Development consists of a tunnel driven on the vein a distance of 200 ft. At the portal of the tunnel a shaft has been sunk on the vein to depth of 30 feet.

Idle.

Pine Creek Tungsten Mine, comprising 12 claims, is situated on Morgan Creek, which is tributary to Pine Creek from the north, about

PHOTO. 16. Pine Creek Tungsten Mine, Pine Creek, Bishop, California. Photo by John M. Hague.

20 miles (air line) west of Bishop; elevation, 10,500 to 11,000 ft.; owner, *United States Vanadium Corp.*, R. J. Hoffman, president, 30 East 42d St., New York; Clarence H. Hall, superintendent, Bishop, Calif. This property was located in 1918 after which two or three attempts were made to operate it, the most serious effort having been made by the *Tungsten Products Co.*

The deposit is a product of contact metamorphism. It occurs between a dolomitic footwall and a granitic hanging wall. Its strike is north-south; the width varies from 15 ft. to 50 ft. The mineralization consists of scheelite, molybdenite, chalcopyrite, with a little silver and gold, in a garnetiferous gangue. In general, the higher-grade scheelite ores occur near the footwall, while molybdenite values are greater in the vicinity of the hanging wall. The ore is reputed to carry $1\frac{1}{2}$% WO_3, 1% MoS_2, 1% Cu, about $\frac{1}{2}$ oz. silver and .01 oz. gold. Two orebodies, with a 200-ft. barren zone between, have an aggregate length

of 1000 ft. Practically all of the ore so far developed lies to the north of the crosscut.

Development consists of crosscut tunnel driven N. 30° E. 2500 ft. At 1700 ft. a raise connects with upper tunnel and glory hole, a distance of 375 ft. Upper tunnel is 325 ft. above main tunnel and is 500 ft. in length. A sub-level has been developed below the upper tunnel through a winze 80 ft. deep. At the end of the lower crosscut, drifts have been driven south 300 ft. and north 5800 ft. A series of raises has been put up from this drift 145 ft. They will be connected to form a sub-level 100 ft. below the winze sub-level. A shrinkage stope 300 ft. long, about 15 ft. to 20 ft. wide and 145 ft. high has been completed. There is now remaining in this stope 18,000 tons of broken ore.

The ore is trammed to the head of the mill in 6 to 8 one-ton car trains by storage battery locomotives. From grizzly to 12 by 20 jaw crusher, to belt over which is suspended a Stearns magnet to remove tramp iron, to 3-ft. Symons crusher, to 33° inclined conveyor to 230-ton crushed-ore bin. From this point on, the mill is under construction. It is a combination of flotation and concentration and the following machines will be used: Symons shaking screen, two 5-ft. ball mills, Jeffrey screen, Richards 3-spigot pulsating classifier, twin-unit Denver flotation cells and 4 Denver Sub-A cells and 14 concentrating tables, 8 of which are now installed and working.

The tables make a 50% scheelite concentrate which goes through a drying screw-conveyor to a Dings magnetic separator, to sacks. The molybdenite concentrates from flotation cells go to a 10-ft. Dorr thickener, to a 4-ft., 2-disc filter, through a drying screw conveyor to sacks; copper concentrates, carrying the gold and silver, from flotation cells to cone thickener, to filter.

The plant, now running 50 tons per day, when completed will have a capacity of 300 tons per day.

The surface plant at the mine consists of modern blacksmith shop, machine shop, compressor plant and assay office. All equipment in both mill and surface plant is operated by motors, electric power being supplied by Southern Sierras Power Co. Comfortable bunk houses and cottages can accommodate more than 100 men. The mine surface plant, mine and crushing plant at top of mill are all connected by completely enclosed snow sheds.

At present 60 men are employed, 10 underground, the other 50 on mill construction and the building of a road up Pine Creek from Brown's Camp.

Bibl.: State Mineralogist's Report XVII, pp. 301-302; XXII, pp. 511-512.

Round Valley Tungsten Mine, comprising 8 claims, 11 miles northwest of Bishop on the north slope of the Tungsten Hills on edge of Round Valley, has been leased to the *Pacific Tungsten Corp.,* 5514 Wilshire Blvd., Los Angeles; elevation, 5350 ft.; owner Al Stevens, Bishop, Calif.

Six men are employed on rehabilitation work.

(Later): Lessee has driven crosscut 250 ft. E. to granodiorite-limestone contact. This contact, in places, up to 6 ft., in width, carries scheelite, disseminated in a gangue of garnet and epidote, with little

or no quartz. The following mill was erected: 10 in. by 20 in. jaw crusher, 14 in. by 30 in. rolls, elevator to 12 mesh screen, oversize to 4-ft. by 4-ft. ball mill, 2 Overstrom tables, rotary dryer, Stolle electrostatic separator. Operated a very short time and shut down, supposedly, account of ore shortage.

Bibl.: State Mineralogist's Reports XVII, pp. 302-303; XXII, p. 512; U. S. G. S. Bull. 640-L, p. 247.

Shannon Creek Tungsten Deposit (Buckshot) is on Shannon Creek, about 4 miles north of Big Pine and between four and five miles west of the Owens Valley highway; elevation about 5700 ft.

The deposit, having a northwest-southeast trend, occurs at the contact of granite and limestone. The scheelite is disseminated through a garnetiferous gangue, varying in width from 7 ft. to more than 15 ft. Idle.

Tungsten City Milling Co., Raymond Stolle, P. O. Box 641, Bishop, Calif., has leased the Tungsten City property from J. V. Baldwin, of Los Angeles. This property has been variously known as the *Aeroplane Group* and the *Standard Tungsten Mine*. The lessees have to date confined their operations to the treatment of tailings from the old mill.

The following described mill was built and put into operation in January, 1937. It has been operating continuously on the tailings and had successfully treated about 20,000 tons by the middle of September, 1937. A caterpillar tractor with a 1¼-yd. scraper delivers material to the foot of an inclined grizzly, drag-line to 40-ton bin, elevator to 12-mesh screen, oversize saved to grind later, under size to Stolle electrostatic separator, tailings are stacked by a belt conveyor. All machines are connected to a dust-collecting system. A satisfactory recovery is made and it is reported that they market a 72% WO_3 concentrate. The entire treatment is dry. Capacity is 120 tons per day. Eight men are employed.

Waucoba Tungsten Deposit. It comprises 7 claims situated on the east slope of the Inyo Range, in T. 11 S., R. 37 E., M. D. M., 22 miles southeast of Big Pine, and 3 miles southwest of Waucoba Springs. The distance from Big Pine over the Waucoba-Saline Valley road is 40 miles; owners, Stuart Bedell and Clyde McBride, of Big Pine.

Scheelite occurs in a belt of limestone some 100 feet in thickness between beds of quartzite. The general strike is N. 30° W., with a dip of 50° to 60° N.E.

On contact of quartzite and limestone, a shaft has been sunk on an inclination of 60° to depth of 40 ft., developing 4 ft. of ore, reported to carry 2% WO_3. Southeast of these workings is a massive outcrop of quartz, on which a shaft has been sunk to a depth of 30 ft.

The vein quartz is mineralized with copper silicates, and copper carbonates, and said to carry $2.00 in gold. The property was located some 50 years ago as a copper mine.

About 1½ miles north of the property two claims have been located along a garnetiferous outcrop, which is about 6 ft. in thickness and can be traced for distance of 200 ft. Scheelite occurs associated with fluorite. Developed by a series of open cuts. Two men are employed on development.

METAL MINING CLAIMS, INYO COUNTY

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Adamson		6 S.	30 E.	D. B. Adamson, Bishop	160	Herein
Advance Army		8 S.	31 E.	John H. Armington, Bishop	360	
Ajax Group (Carbonate)		24 N.	1 E.	New Southerland Divide Mining Co., Trona	100	R. XV, pp. 89-90
Alabama Mine	15, 22	21 S.	45 E.	Alabama Silver Mining Co., 8266½ W. Norton, Hollywood	16.84	Herein
Alabama-Mohawk Mine		15 S.	35 E.	Frank Hilton, et al., Lone Pine	100	
Alice Mine	4, 9	21 S.	45 E.	Alice Silver Mining Co.	20.63	
Alvah Mine		16 S.	38 E.	Eleuterio Diaz, Keeler	20.65	
American Mine		20 N.	5 E.	J. W. Stocker, Death Valley Junction	100	R. XV, p. 71; XXII, p. 476; herein
American Mine		22 S.	45 E.	F. N. Banta	20	
American Eagle Group		19 S. 20 S.	41 E.	W. R. Wallace, Darwin	380	See Wonder Mine
American Group	31	24 S.	44 E.	Slate Range Minerals Mining Co.	70.002	
Anaconda Mine	4	21 S.	45 E.	Death Valley Mining Co., Trona	20.67	
Anderson Placers (see Marble Canyon Placers)		10 S.	37 E.	H. W. Anderson, et al., Big Pine	800	
Anthony Mine (Gold Bug)		22 S.	44 E.	Mrs. Ada Norris, Trona	100	R. XXVIII, pp. 368-369
Antinomium Group		21 S.	46 E.	Geo. Montgomery, et al., 1009 Great Republic Life Bldg., Los Angeles	42.33	
Apex Cons. Group	9, 10, 15, 16	20 N.	8 E.	Tecopa Cons. Mining Co., Tecopa	75.93	
Arctic Group		13 S.	33 E.	Arctic Gold & Silver Mining Co., Independence	4.12	
Argenta Group		18 S.	45 E.	Ed. L. Wright, Trona	360	
Argus Group		20 S.	42 E.	A. H. Leonard, Trona	120	
Argus Group		23 S.	41 E.	Paul Schultz, Darwin	240	
Argus Mines		19 S.	41 E.	L. T. Lynn, Darwin	60	
Argus-Sterling Mine		20 S.	41 E.	A. C. Taylor Estate, Darwin	20	R. XVII, p. 283; XXII, pp. 476-477; herein
Aries Cons. Group		16 S.	38 E.	Newton Development Co.	47.65	
Armagh Mine		16 S.	38 E.	Geo. Jackson, Keeler	20.64	
Armistice Mine		20 N.	3 E.	Carl D. Engle, Shoshone	40	
Arondo Mine		23 S.	43 E.	Alice H. McIntosh, Judge Ross Avery, Trona	580	R. XVII, p. 281; XXII, p. 472
Ashford Mine (Golden Treasure)				H. J. and L. R. Ashford, Shoshone	520	R. XV, pp. 78-79; XXII, p. 469; herein
Astor Mint Group		20 S.	44 E.	Dan E. Lane, et al., Trona	240	
Auguste Mine		16 S.	38 E.	C. H. Crohn, Keeler	20.661	
August Group		22 S.	38 E.	F. J. Sanders, et al., Santa Barbara	2880	
Badgette-Lafayette		16 S.	38 E.	Marie Badgette, Keeler		
Ballarat Mining Co.		21 S.	45 E.	R. H. Thompson, et al., Trona	620	R. XXVIII, p. 376
Baushey Mine		16 S.	38 E.	Baushey Silver Quartz Mining Co.	6.91	
Baxter Mine		23 N.	7 E.	J. P. Madison, Shoshone	20	R. XV, p. 88; XVII, p. 283; XXII, p. 477; herein
Bedell Group		10 S.	37 E.	David T. Bedell, Big Pine	320	Herein
Bedell Mine (Daisy Mine)		10 S.	37 E.	David T. Bedell, Big Pine	160	R. XV, p. 94; XVII, p. 285; XXII, p. 483
Belmont Mine		16 S.	39 E.	W. L. Hunter Estate, Keeler	20	R. XVII, p. 283; XXII, p. 477; herein

Bernon Mine	14	19 S.	40 E.	Patrick Reddy	19.95	
Big Bell Cons. Group	29, 12	30 N.	1 E.	819 Parkview Ave., Los Angeles	42.32	
		15 S.	46 E.			
Big Dike Group		13 S.	33 E.	Albert Blunt, et al., Independence	100	
Big Horn Mine		14 S.	37 E.	Sam Spear and M. A. Wilson, Lone Pine	165	R. XXII, 465-466; herein
Big John Group		12 S.	36 E.	Fred F. Hughes, Independence	160	
Big Silver Mine (Essex)		13 S.	38 E.	Big Silver Mining Co., Los Angeles	120	R. XXII, pp. 477-478; herein
Big Sister Group	11, 12, 13	7 S.	31 E.	Tungsten Mines Co.	41.284	R. XV, p. 133; XVII, pp. 304-305; XXII, p. 512; U. S. G. S. Bull. 640b
Big "T" Group		21 S.	40 E.	Russell Lange, et al., Darwin	80	
Big Wedge				See Union Mines		
Birthday Group		23 S.	41 E.	Peter E. Erickson, Darwin	80	
Bishop Silver Cobalt Mines	14	9 S.	31 E.	Jack O'Brien, et al., Bishop	120	Herein
Bishop Tungsten Co.		7 S.	32 E.	Joseph Rossi, Bishop	108	Herein
Black Canyon Group	34	7 S.	34 E.	Black Canyon Gold Mining Co.	58.151	See Mineral Point Mine, XXII, p. 489-490
Black Cat Group	12, 13	7 S.	31 E.	Tungsten Mines Co.	208.799	R. XV, p. 133; XVII, pp. 304-305; XXII, p. 512
Black Eagle Gold Mine		13 S.	36 E.	A. T. Smith, San Clemente	45	R. XV, p. 75; XVII, p. 279; XXII, p. 466; herein; U. S. G. S. Bull. 540, p. 116
Black Mountain Group		23 N.	3 E.	James Edwards, et al., Shoshone	60	
Black Prince Mine		19 N.	8 E.	Tecopa Cons. Mining Co., Tecopa	20	
Black Rock Group		20 N.	8 E.	Unknown	120	R. XXII, pp. 478-479
Blue Belle		20 S.	42 E.	Estate of J. C. Cress	40	
Blue Bell Group		17 S.	45 E.	Ed. Attaway, et al., Trona	160	
Blue Dick Mine		20 N.	8 E.	Henry Lang, Tecopa	80	R. XV, p. 89; XVII, p. 283; XXII, p. 479; herein
Blue Eagle Group		13 S.	36 E.	Oscar Fausel, Independence	80	Herein
Blue Eagle Mines		20 S.	42 E.	J. H. Townsend, et al., Darwin	120	
Blue Eagle Mine		21 S.	39 E.	C. W. Woodson, et al., Los Angeles	60	
Blue Jacket Group	19, 20	24 N.	3 E.	Furnace Valley Copper Mining Co.	34.89	
Blue Moon Group		23 S.	41 E.	Wm. T. Lange, Darwin	160	
Blue Rock Mine		21 S.	40 E.	Walter Palmer, et al., Darwin	80	Herein
Bluff Group		16 S.	38 E. 39 E.	Cerro Gordo Mines Co.	102.375	
Boomerang Mine		13 S.	33 E.	Boomerang Gold Mining Co.	3.43	
Bonanza Group		20 S.	40 E.	L. A. Lee, Darwin	140	Herein
Bonanza Mine		21 S.	40 E.	Western Cons. Gold Mines, Ltd.	820	
Brick Mine	20	24 N.	3 E.	Furnace Creek Copper Mining Co.	1.41	
Brown Bear Group		14 S.	37 E.	J. Emil Smed, Lone Pine	60	
Brown Monster Mine	3	14 S.	36 E.	A. W. Eibeshutz	17.22	
Brown Monster Reward (Reward Brown Monster)		14 S.	36 E.	Guy Eddie, et al., 543 Rives-Strong Bldg.	130	R. VIII, p. 263; XII, p. 136; XIII, p. 180; XV, p. 83; XXII, p. 473; herein; Register of Mines, Inyo Co., 1902; Rept. of Director of the U. S. Mint, 1883, p. 160; U. S. G. S. Bull. 540, pp. 116-118; U. S. G. S. Professional Paper 110, pp. 121-122
Bull Domingo		6 S.	35 E.	P. N. Johnson, 302 E. Anaheim Blvd., Long Beach	120	Herein
Bunker Hill		6 S.	35 E.	Bunker Hill Mining Co., 689 E St., San Bernardino	240	R. XVII, p. 283; XXII, p. 479; herein
Burro, New Discovery and Gem Mines		22 S.	44 E.	R. D. Warneck (deceased), Trona	100	R. XV, pp. 81-82; XVII, pp. 470-471; XXVIII, 364-368; herein
Burro Mine		20 S.	44 E.	D. D. Corum, Trona	20	
Burros Mines		13 S.	37 E.	C. D. Carll, Independence	60	
Buster Brown		22 S.	45 E.	L. E. Cain, et al., San Pedro	60	

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Buster Group		24 S.	42 E.	Chas. E. Saltman, et al., Trona	40	
California Queen No. 4		24 S.	44 E.	California Queen Mining Co., Trona	120	XXII, p. 479; herein
California Smelting & Refining Co.		19 S.	41 E.	California Smelting & Refining Co.		Herein
Campbird Group of Mines		21 S.	45 E.	J. V. Leigh, 307 Union League Bldg., Los Angeles	200	R. XXII, pp. 479-480
Canyon No. 2 Mine	31, 32, 6	30 N. 29 N.	1 E.	Keane Wonder Mining Co.	27.98	
Carbonate Mine (Queen of Sheba)				New Southerland Divide Mining Co., 156 Montgomery St., San Francisco	140	R. XV, pp. 89-90; XXII, p. 480; herein
Cardinal Gold Mining Co. (Wilshire-Bishop Creek)		8 S.	31 E.	Cardinal Gold Mining Co., Bishop	680	R. XV, p. 85; XVII, pp. 281-292; XXII, p. 474; herein
Carriboo Mine	3	21 S.	45 E.	Carriboo Silver Mining Co.	20.63	
Casey Mine		15 S.	38 E.	Thomas Casey, Lone Pine	20	
Cashier (Harrisburg Mine)		18 S.	45 E.	J. P. Augerebery, Trona	140	XV, p. 76; XXII, p. 467; herein
Cecil "R" Mine		23 S.	43 E.	M. J. Sherlock, Trona	20	R. XXVIII, p. 366; herein
Cerro Gordo Mine		16 S.	38 E.	Cerro Gordo Mines Co., San Jose	550	R. VIII, p. 250; X, p. 213; XV, pp. 90-92; XX, pp. 185-187; XXII, pp. 280-482; herein; U. S. G. S. Bull. 540, pp. 97-109; Professional Paper 110, pp. 106-116
Cerro Gordo Extension Mine (Royal)		16 S.	39 E.	Mrs. R. C. Spear, Lone Pine	140	R. XV, p. 106; XVII, p. 294; XXII, pp. 497-498; herein
Cerrusite		16 S.	41 E.	W. A. Reid, Keeler	120	Herein
Challenge	10	21 S.	45 E.	Challenge Silver Mining Co., 811 W. 7th St., Los Angeles	11.66	
Champion Group		20 N.	4 E.	Orin F. Blabon, Death Valley	240	
Champion		20 N.	4 E.	S. M. Barbour, et al, Tecopa	180	R. XXII, p. 468
Champion Mines		20 N.	4 E.	Ben Hartzinger, et al., Tecopa	240	
Chesamac		20 S.	45 E.	Donald McDonald, Los Angeles	120	R. XXII, p. 482
Chloride-Bromide Group		16 S.	39 E.	Ellen Maysen, et al., Darwin	180	
Chloride Cliff Mine		30 N.	1 E.	W. R. McCrea, et al., Beatty, Nevada	640	R. XV, pp. 76-77; XXII, p. 467; U. S. G. S. Bull. 285, pp. 72-73
Christmas Gift Mine		19 S.	40 E.	W. L. Skinner, et al., Darwin	100	R. VIII, p. 226; X, p. 211; XVII, p. 284-285; XXII, p. 482; U. S. G. S. Bull. 580A, pp. 10-12
Cinnamon Mine		14 S.	38 E.	F. M. Hess, et al., Lone Pine	20	R. XVII, p. 279; XXII, p. 467
Cleveland		10 S.	34 E.	Mary Dunlap Mears, Big Pine	320	R. XVII, p. 279-280; XXII, p. 467
Cliff		6 S.	36 E.		120	R. XV, p. 93; XXII, p. 470
Colorado Group		26 N.	1 E.	Carroll D. Willis, Death Valley	140	
Colorado Group		18 S.	41 E.	A. G. Miller, Darwin	120	
Columbia Mine	31	19 S.	41 E.	Wagner Assets Realization Corp., Darwin	20.661	R. XV, p. 93; XVII, p. 285; XXII, p. 482; U. S. G. S. Bull. 580, pp. 17-18
Comet No. 1 and No. 2 Mines	13	20 N.	5 E.	John F. Imel, 503 Sun Fidelity Bldg., Los Angeles	41.008	
Commetti Mine		10 S.	34 E.	Cometti Mines Co., Leased to Ellis Rowe, Pasadena	215	R. XVII, p. 280; XXII, p. 468
Comstock Mine	4	21 S.	45 E	Comstock Silver Mining Co.	20.61	
Contact Mines		15 S.	41 E.	Roy Albin, Darwin	80	
Continental Group		20 S.	39 E.	Pioneer Mfg. Co., Darwin	160	

Copper Bar Group	10, 15	23 N.	3 E.	Butte & Greenwater Copper Co.	75.30	
Copper Bell Group		14 S.	40 E.	Geo. F. Crook, Big Pine	80	
Copper Bell Group	20, 21, 29	24 N.	3 E.	Furnace Creek Extension Copper Co.	387.04	
Copper Glance Group	27	24 N.	3 E.	Greenwater-Death Valley Copper Co.	304.163	
Copper Queen Group	12, 7	6 S.	36 E. 37 E.	James Jacoby, et al., Big Pine	91.49	
Copper Queen Group No. 2	31	24 S.	44 E.	T. A. Wells, et al.	17.385	
Copper World Group	10, 11, 14, 15	7 S.	39 E.	Ulida Cons. Copper Co.	152.295	
Cosmopolitan Group		20 S.	39 E. 40 E.	Paul Wilbur, Darwin	340	
Coso Divide Group		21 S.	39 E.	Wm. S. Lewis, Darwin	340	
Coso Iron Deposit		19 S.	38 E.	G. W. Dow, Lone Pine	440	R. XV, p. 87; XXII, p. 475
Coso Molybdenite		20 S.	38 E.	H. A. Clark, et al., Darwin	240	
Coso Pass Group		20 S. 40 E.	39 E.	E. H. Rushton, Darwin	180	
Coso Quicksilver Deposit		22 S.	38 E.	F. J. Sanders, 1434 Garden St., Santa Barbara	1000	R. XXVI, pp. 58-63
Coso View Mine		21 S.	40 E.	M. O. and L. E. Early, Lancaster	20	
Crater		10 S.	37 E.	F. B. Crater, Big Pine	160	
Crawford Tungsten Deposit		7 S.	30 E.	Cord Crawford, Bishop	80	
Curran Group		21 S.	45 E.	Ballarat Mining Corp., et al., Trona	520	R. XXVIII, pp. 366, 368
Custer Group		12 S.	36 E.	J. C. Baxter, Independence	300	
Custer		19 S.	40 E.	Frank Long, et al., Pasadena		R. XV, p. 94; XVII, p. 285; XXII, pp. 482, 483; U. S. G. S. Bull. 580; pp. 15, 16
Darwin-Keystone	24, 25, 19, 30	19 S.	40 E. 41 E.	A. A. Rubel, Darwin	500	
Davenport Group		23 S.	45 E.	Nellie E. Bliss, Leased to Geo. Wyman & M. W. Sweetzer, Trona	120	
David Group		10 S.	37 E.	Mrs. J. E. Davis, Big Pine	20	
Davis Mine		10 S.	37 E.	Chas. Davis, Big Pine	20	
Death Valley-Wonder Mine		17 S.	44 E.	Geo. E. Cook, et al., Trona	200	
Defiance		19 S.	40 E.	J. S. Taber	19.51	
Defiance-Independence-Thompson	1, 2, 11, 12, 13, 14, 23, 25, 26, and 30	19 S.	40 E. 41 E.	Wagner Assets Realization Corp., Darwin	2349.121	R. VIII, p. 226; X, p. 211; XII, p. 24; XVII, p. 285; XXII, p. 483. Report of the Director of the Mint, Precious Metalsin U. S., 1883-1884. U. S. G. S. Bull. 580, pp. 13-14
Delaware Mine	15	21 S.	45 E.	Delaware Silver Mining Co.	20.63	
Del Norte Group		17 S.	44 E.	J. P. McCafferty, et al., Los Angeles. Leased to Panamint Mining & Milling Co., Roy C. Troeger, Los Angeles	120	
Dennis Jr., Mine	5	13 S.	36 E.	H. B. Whiteside	15.376	
De Sota Group		20 S.	38 E.	See Coso Molybdenite	120	
Doctor Mine	26	24 N.	3 E.	United Greenwater Copper Mining Co.	6.69	
Dolomite Mine	4	16 S.	37 E.	Emil Fernandez	18.08	
Don Juan Mine	4, 9	21 S.	45 E.	Panamint Cons. Mining Co.	20.661	
Driver Mine	13, 14	19 S.	40 E.	Patrick Reddy	14.45	
Echo Guilt Edge Group	1	27 N.	2 E.	The Echo Gilt Edge Mining Co.	87.050	
Eclipse Mine	34	19 S.	42 E.	Lone Star & Eclipse Gold Mining Company	20.04	
Eclipse Mine	34, 3	13 S. 14 S.	36 E.	Isaac Friedlander	36.83	

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Eclipse No. 1 and No. 2 Mines	13, 18	20 N.	5 E. 6 E.	John F. Imel, Shoshone	41.322	
El Diablo Mining Co. (Standard)		7 S.	31 E.	El Diablo Mining Co., Bishop	160	Herein. R. XV, pp. 129-130; XVII, p. 303, XXII, p. 512. U. S. G. S. Bull. 640, pp. 243-245
Ella Group of Mines		17 S.	39 E.	Wm. Betts, 331 W. 31st St., Los Angeles	160	R. XXII, p. 483; herein
Emergency Group Mines		6 S.	36 E.	Harry Brown, et al., Big Pine	160	Herein
Emigrant Group	2, 3	29 N.	1 E.	Vermont Rose Mining Co.	109.352	
Emigrant Springs Mine (Saddle Rock)		18 S.	45 E.	Emigrant Springs Mining Co., Stove Pipe Wells	80	Herein
Ernestena Group		11 S.	35 E.	Ralph Hazlett, et al., Big Pine	280	
Essex Group				See Big Silver Mine		
Esta Bien Mine	20	24 N.	3 E.	Butte Furnace Range Copper Co.	73.541	
Estella Fraction Mine	27	24 N.	3 E.	Greenwater Death Valley Copper Co.	20.661	
Estelle and Morning Star Mine		16 S.	38 E.	Estelle Mining Corp., Keeler	1400	R. XV, pp. 108-109; XVII, p. 286; XX, pp. 187, 189; XXII, pp. 483, 484; herein; U. S. G. S. Bull. 540, p. 110; U. S. G. S. Professional Paper 110, pp. 116, 117
Eureka Mine	10, 15	21 S.	45 E.	Geo. M. Pinney, et al.	21.02	
Eureka No. 2 Mine	13	19 S.	40 E.	Inyoreka Gold Mining Co.	20.27	
Eureka Group	31, 32	11 S.	35 E.	R. C. Chambers	54.061	
Fairbanks Mine		19 S.	40 E.	Alex Ruona, Darwin	160	
Fearless Mine	12	6 S.	33 E.	W. J. Monahan, Bishop	80	
Feldman Tungsten Mine		23 S.	38 E.	Frank Feldman, Independence	100	
Fernando Group of Mines	24	19 S.	40 E.	Theo. Peterson, Darwin	140	R. XXII, pp. 484, 485
Flapjack Group	4, 5	28 N.	3 E.	D. J. Cushman	26.75	
Fortune Group		22 S.	45 E.	John H. Thorndyke, Trona	80	
Francis Group		13 S.	37 E.	Chester A. Wilson, Lone Pine	100	
Furnace Creek Group	16	24 N.	3 E.	Furnace Creek Copper Co.	93.35	
Georgia Queen		22 S.	45 E.	Harold Goodwin, Trona	80	
Gibralter Mine (Big Horn)		22 S.	45 E.	John Thorndyke, Trona	80	R. XV, p. 95; XXII, p. 485; XXVIII, p. 361; herein
Gold Basin Mine		23 S.	40 E.	J. H. Allen, et al., Darwin	140	Herein
Gold Bug				See Anthony Mine		
Gold Crown Copper Mine	35	24 N.	3 E.	Greenwater Death Valley Copper Co.	20.15	
Gold Group		22 S.	45 E.	H. H. Thompson	169.73	
Gold Hill Mine		21 N.	1 E.	Death Valley Mining Co., Trona	19.66	
Gold Hill Mine		22 S.	46 E.	Fred W. Grey, et al., 3503 McClintock Ave., Los Angeles	80	R. XXVIII, p. 369; herein
Gold Hill Group		16 S.	38 E.	W. P. Betts, Keeler	60	
Gold Ridge Group		18 S.	38 E.	Western Cons. Gold Mines, Ltd.	400	Herein
Gold Spur Mine		24 S.	45 E.	Unknown		R. XV, pp, 77, 78; XXII, p. 469; herein
Gold Standard Mine		14 S.	38 E.	Col. A. E. Montieth, et al., Keeler	600	Herein
Gold Star Group		9 S.	37 E.	W. E. McDonald, et al., Big Pine	80	
Gold Star Group		23 S.	43 E.	C. Ferge, Trona	40	
Golden West Group		23 S.	41 E.	E. C. Wasmuth, Trona	240	

Grand Mine	14	19 S.	40 E.	Wm. D. Brown, et al.	20.661	
Grand View Mine	4	21 S.	45 E.	Death Valley Mining Co., Trona	17.97	
Grand View Group		19 S.	40 E.	Alex Ruona, Darwin	220	
Great Group		7 S.	35 E.	C. B. Wilkerson, et al., Bishop	240	
Green Eyed Monster		13 S.	35 E.	Green Mountain Gold & Silver Mining Co., Independence	20.67	
Grubstake Group		20 S.	43 E.	J. E. Ratcliffe, Trona	120	
Gunsite Mine		20 N.	8 E.	Tecopa Consolidated Mining Co., 722 S. Oxford Ave., Los Angeles	20	R. XV, pp. 95, 96; XVII, pp. 286, 287; XXII, p. 485; XXIII, pp. 264, 266; herein. Report of the Director of the Mint, Precious Metals in the U. S., 1883, p. 166
Gunsite and Extension Mines		20 N.	8 E.	Los Angeles Mining & Smelting Co.	33.93	
Gypsy Queen Mine		12 S.	33 E.	Frank Thomas, Big Pine (last known owner)	200	Herein
Gold Tooth Mine		23 S.	44 E.	A. R. Greenslitt, et al., Trona	40	R. XXVIII, p. 369
Gold Tooth Extension		23 S.	45 E.	R. E. Baughman, et al., Trona	20	
Gold Wedge Mine		6 S.	35 E.	A. T. Wilkerson, Bishop	160	Herein
Golden Eagle Group		10 S.	34 E.	Fred A. Armstrong, Big Pine	60	
Golden Eagle Mine		14 S.	37 E.	John C. Anton, Lone Pine	20	R. XV, p. 78; XXII, p. 469; herein
Golden Gate Group		20 S.	40 E.	J. O. Nelson	111.111	
Golden Gate King		19 S.	41 E.	C. C. King, Darwin	200	
Golden Gate Syndicate, Tungsten Group		7 S.	32 E.	J. J. Dunlap, Bishop	240	
Golden Marvel Mines		8 S.	36 E. 37 E.	Lucien Anderson, Big Pine	480	
Golden Rod (Marigold Mine)		20 S.	40 E.	L. W. Lee, Darwin	20	R. XV, p. 82; XXII, p. 471; herein
Golden Treasure				See Ashford Mine		
Golden Treasure Group		22 S.	47 E.	Louise B. Grantham, Shoshone	80	
Hallelujah No. 3 Placer		10 S.	37 E.	Dr. Vaugh, et al., San Pedro	160	
Harrisburg				See Cashier		
Harrison Mine	15, 22	21 S.	45 E.	Harrison Silver Mining Co.	20.6	
Hayseed Gold Mine	28	29 N.	3 E.	Hayseed Mining Co., Death Valley Junction	18.8	
Hemlock Silver Mine (Silver Peak)	11, 14, 15	21 S.	45 E.	Hemlock Silver Mining Co.	23.60	R. XXII, p. 500; XXVIII, p. 362
Hidden Treasure Con. Group	21, 28, 33	29 N.	3 E.	Lee Hidden Treasure Gold Mining Company	133.162	
Hidden Treasure Group	3, 4	14 S.	36 E.	Reward Gold Mines Co.	73.715	
Highland Chief Mine		13 S.	37 E.	Thomas Hancock, Lone Pine	40	
Hillside Group		23 S.	42 E.	Lee Taylor, Brown	60	
Hirsh Mine	3	14 S.	36 E.	Nathan Rhine, Independence	15.98	
Holy Roller		22 S.	44 E.	A. C. Porter, Trona	20	XV, p. 79; XXVIII, p. 370
Homestake Group		18 S.	40 E.	E. Lockhart, et al., Darwin	160	
Hoot Owl Iron Deposit		23 S.	43 E.	Lloyd Helm, Inyokern	20	
Hope Group		17 S.	44 E.	R. G. Nelson, et al., Trona	120	
Hornspoon Group		19 S.	45 E.	Chris. Wicht, Trona	45	R. XXVIII, p. 370
Hortense Group		21 S.	40 E.	Margaret Wilbur, Darwin	160	
Hudson Group				See Big Silver Mine		
Hudson River Mine	21, 22	21 S.	45 E.	Hudson River Mining Company	20.53	
Ibex Mine (Arcturas) (Lead-Silver-Zinc)		20 N.	5 E.	Standard Engineer's Mining Corporation of Nevada, Tecopa	240	R. XV, pp. 96, 97
Ida Mine	10, 11, 15	21 S.	45 E.	Geo. M. Pinney, et al.	24.37	
Ignacio (Formerly Ygnacio)		16 S.	38 E.	Cerro Gordo Mines Co., San Jose	3.66	R. W. Raymond, Mineral Resources West of Rocky Mts., 1870, p. 17; S. M. B. Reg. of Mines, Inyo County, 1902; XV, pp. 97, 98; XVII, p. 287; XXII, p. 485.

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Independence Group		13 S.	33 E.	Vera Oerding, et al., Independence	60	
Independence Mine	14	19 S.	40 E.	A. D. Meyers, Darwin	13.11	
Independence & Thompson Mine		28 N. 27 N.	3 E. 2, 3 E.	Inyo Cons. Mines, Inc.	440	R. VIII, p. 226;, X, p. 211; XV, p. 98; XVII, pp. 287, 288; XXII, pp. 486, 487. Reports of Director of Mint. Precious Metalsin U. S., 1883, p. 164; 1884, p. 103; U. S. G. S. Bull. 580, pp. 14, 15
Iron Dike Group		11 S.	37 E	L. B. Pickett, et al., Big Pine	80	
Iron Gossan Group	34, 35 2	20 N. 19 N.	10 E.	Wm. H. Beck	106.131	
Iron Mask Group		21 S.	40 E.	Ralph L. Tuttle, et al., Darwin	160	
Iron Nugget Placer		10 S.	37 E.	F. B. Krater, et al., Big Pine	320	
Ironsides Group		15 S.	38 E.	G. F. Marsh, Lone Pine	160	
Ironsides Mine				See Burgess Mine		R. XVII, p. 280; XXII, p. 469
Iroquois Group		19 S.	39 E.	John Stewart, Darwin	60	
Jackass Silver Mine	13	19 S.	40 E.	Black Metal Mining Co., Los Angeles	17.13	R. XVII, p. 288; XXII, p. 487
Jessie Mae Silver Mine	4, 8	21 S.	45 E.	Panamint Cons. Mining Co.	25.49	
Jim Dandy		24 S.	45 E.	J. W. Montgomery, et al., Trona	20	
Josephine-Yucca Mines		20 S.	40 E.	Louis D. Owen, Darwin	120	R. XV, p. 85; XXII, p. 474; XII, p. 138; XIII, p. 181
Journigan's Group		14 S.	38 E.	Roy Journigan, Trona	100	
July Group		11 S.	43 E.	Chas. M. Pinney, Beatty, Nevada	40	
Jumbo Group		22 S.	43 E.	Fred A. Alley, et al., Trona	120	
Jumbo Group		7 S.	35 E.	R. W. Fordson, et al., Bishop	80	
Jumbo Mine		13 S.	36 E.	Clarence Johnson, Independence	120	R. XXII, pp. 469-470
Kane Group of Mines		23 S.		Belcher Extension Mining Co., Jersey City, N. J.	300	R. XXII, pp. 487, 488
Kate Consolidated Group		24 N.	3 E.	Patrick Clark	33.63	
Kate Group		24 N.	3 E.	Wm. J. Cleary	36.071	
Keane Wonder Mines	31, 32 6	30 N. 29 N.	1 E.	Coen Companies, Inc., 610 S. Broadway, Los Angeles	464.329	R. XV, pp. 79, 81; XXII, p. 470
Kearsarge Mine		13 S.	33 E.	Clifford T. Gates, Independence	120	R. XVII, p. 280; XXII, p. 470
Keeler Mines		17 S.	38 E.	Adolph Ramish, 972 4th Ave., Los Angeles	460	
Kempland Group	23, 18, 19	24 N.	2 E. 3 E.	Kempland Copper Company	284.30	
Kennedy Mine		21 S.	46 E.	Geo. Montgomery, et al., 1009 Great Republic Life Bldg., Los Angeles	20.661	
Keynote Mine		14 S.	37 E.	Golden Princess Mining Co., Lone Pine	140	R. XII, p. 138; XIII, p. 181; XV, p. 81; XXII, p. 470; Report of Director of U. S. Mint, 1883, p. 159. U. S. G. S. Bull. 540, p. 112; U. S. G. S. P. P., 110, p. 118
King Fissure Group		22 S.	45 E.	Frank H. Long, Trona	320	
Klad Group		20 S.	40 E.	C. Al. Draper, Darwin	280	
Krater Van Norman Group of Placers				F. B. Krater, et al., Big Pine	160	

Lane Mine		19 S.	41 E.	Wagner Assets Realization Corp., Darwin	20	
Last Chance Group	13, 18	19 S.	40 E. 41 E.	Wagner Assets Realization Corp., Darwin	60.371	R. XII, p. 24; XIII, p. 32; XV, pp. 98-99; XVII, p. 288; XXII, p. 488; U. S. G. S. Bull. 580
Last Hope Group		9 S.	37 E.	Geo. M. Kruze, et al., Big Pine	120	
Lead Hill Mine	17, 20	12 S.	37 E.	Sam G. Musser, Big Pine	20.661	
Lebanon Mine		20 S.	40 E.	F. E. Maxwell, Darwin	20	
Le Cyr Iron Deposit		18 S.	38 E.	J. R. Le Cyr, Los Angeles	120	R. XXII, p. 475
Lee Mine		16 S.	41 E.	W. A. Reid, et al., Keeler	120	R. XV, pp. 99-105; XVII, p. 289; XXII, p. 488. Report of Director of U. S. Mint, 1883; p. 163
Le Moigne Mine		16 S.	44 E.	W. R. McCrea, Reno, Nevada	240	R. XXII, p. 488
Lester Group		24 S.	45 E.	Edw. M. Lester, et al., Trona	240	
Llewella Mine		15 S.	35 E.	Y. C. Ruiz, Lone Pine	25	
Lewis Group of Placers		10 S.	37 E.	J. G. Lewis, Big Pine	640	
Liberty Group	30, 25	19 S.	40 E. 41 E.	Darwin Silver Lead Mining Co., Darwin	87.566	R. XXII, p. 482; U. S. G. S. Bull. 580, pp. 17-18
Lincoln Mine (Silver Dome)		6 S.	37 E.	A. T. Wilkerson, et at., Bishop	120	R. XVII, p. 289; XXII, pp. 488-489
Little Chief Silver Mine	10, 15	21 S.	45 E.	Little Chief Silver Mining Co.	25.30	
Little Mack Mine		20 S.	42 E.	Otto Seidentopf, Trona	15	
Lone Star Mine	3	20 S.	42 E.	Lone Star Eclipse Gold Mining Company	20.65	
Long John Mine	16, 21	15 S.	37 E.	Jas. A. Walker, 1201 N. Isabel St., Glendale	140	
Los Angeles Placer Group	23, 26	14 S.	38 E.	J. Hartley Taylor	160	
Lost Burro Mine		14 S.	41 E.	W. H. Blackmer, et al., Los Angeles	20	R. XV, pp. 81-82; XXII, pp. 470-471
Lost Burro Mine		14 S.	41 E.	A. McCormick, Darwin	80	
Louisiana Mine		22 S.	40 E.	Wortley Mining Co., Darwin	60	
Lucky Bill Mine		6 S.	30 E.	E. R. Elliott, et al., Bishop	60	
Lucky Boy Mine		13 S.	34 E.	Geo. V. Parker, Independence	160	
Lucky Boy Group		11 S.	37 E.	Saint Edwards, Big Pine	240	
Lucky Day Group		24 S.	44 E.	Harry C. Warton, Trona	100	
Lucky Jim Mine	1, 2, 11, 12	19 S.	40 E.	Wagner Assets Realization Corp., Darwin	329.372	R. VIII, p. 226; X, p. 211; XII, p. 24; XV, pp. 100-101; XVII, pp. 289-290; XXII, p. 489; Report of Director of U. S. Mint, 1883; p. 163; U. S. G. S. Bull. 580, pp. 12-18
Lucky Red Mine		21 S.	41 E.	Inez J. McDonald, Cold Springs	20	
Lucky Slim Group		14 S.	36 E.	Herman Tietz, Jr., Lone Pine	260	
Lucky Strike Group		14 S.	35 E.	R. A. Yannka, Lone Pine	180	
Luella Mine (Formerly Abe Lincoln)		14 S.	35 E.	J. G. McDonald, Ventura	80	
Mabel Mine (Noonday Group)		19 N.	8 E.	Tecopa Cons. Mining Co., Tecopa	25.661	R. XV, pp. 103-104; XVII, p. 293; XXII, pp. 491-492
MacLean Group		13 S.	37 E.	John MacLean, Independence	160	
Magpie Group		10 S.	37 E.	C. C. Cunningham, Los Angeles	100	
Mamie Mine		20 S.	40 E.	E. M. Lorenz, Coso	80	
Mammoth Group		23 S.	41 E.	M. V. Carr, Brown	400	
Marble Canyon Placers		10 S.	37 E.	Helah Anderson, David T. Bedell	960	
March Storm Group	33, 34, 10, 11	12 S. 13 S.	45 E.	Western Lead Mines Co.	329.63	R. XXII, pp. 509-510
Marigold Mines		20 S.	39 E.	W. N. Claus, et al., Darwin	80	R. XV, p. 82; XXII, p. 471
Marigold Mine				See Golden Rod		
Mariposa Mine		20 S.	40 E.	Mariposa Quartz Mining Co., c/o American Bank Bldg., San Francisco	25.661	
Marvel Mine	15	21 S.	45 E.	Marvel Silver Mining Co.	16.71	
Mary Dee		21 S.	40 E.	Geo. Duitz, Darwin	160	
Mature Group		23 S.	44 E.	Peter B. Mathiason	41.322	
Maxmaur-Marguerite Group		20 S.	40 E.	Oliver A. Thorson, Darwin	100	

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Mayflower Group		14 S.	38 E.	M. A. Willson, Lone Pine	80	
Mazourka Canyon Placer Mines		12 S.	35 E.	G. M. Booker, Los Angeles	40	R. XII, p. 139; XIII, p. 182
Mazourka Placer Mines		13 S.	36 E.	O. Brander, et al., Independence	120	
Merry Christmas				See St. George Mine		
Mexican Hat Mine		20 S.	40 E.	George Wolf, et al., Darwin	120	
Michigan Mine	2, 11	19 S.	40 E.	Thomas May, et al.	20.57	
Mineral Hill Group of Mines	29	8 S.	36 E.	R. W. Swank, et al., Big Pine	220	R. XXII, p. 489
Mineral Point Mine (Sanger)	13,14,23,24	7 S.	34 E.	Flynn Bros., et al., Bishop	140	R. XXII, pp. 489-490
Minnietta Mine		19 S.	42 E.	Mrs. Jack Gunn, Independence	105	R. X, p. 212; XV, p. 101; XVII, p. 290, XXII, p. 490; R. W. Raymond, Mineral Resources West of Rocky Mts. 1876
Modoc Mine		19 S.	42 E.	Hearst Estate, San Francisco	160	R. XII, p. 24; XIII, p. 32; XV, p. 101; Report of the Director of the U. S. Mint, 1883, p. 164; 1884, p. 104.
Moffatt Mine		8 S.	31 E.	J. W. Brown, et al., Bishop	140	
Mohawk Mine		24 S.	42 E.	J. C. Boyles, Trona	240	
Mojave View Group		21 S.	41 E.	Vina H. Haggerty, Darwin	160	
Molybdenite Group		20 S.	38 E.	See Coso Molybdenite		
Monarch Iron Group	28, 29	22 S.	43 E.	Geo. Johnson, Jr.	86.042	
Monster Mine (Blue Monster)		14 S.	38 E.	Dr. John MacLean, 2039 W. 68th St., Los Angeles	120	R. XV, p. 101; XXII, p. 490; U. S. G. S. Bull. 540, p. 111. U. S. G. S. Professional Paper 110, pp. 117-118
Monte Carlo Mines (Mount Whitney-Union Mines)		14 S.	36 E.	C. P. Eddie, Lone Pine	300	R. XV, p. 80; XXII, pp. 501-503
Montezuma Mine		10 S.	35 E.	Joseph Bros., Big Pine. Leased to L. W. Sockman, Big Pine	120	R. XIII, p. 32; XV, p. 102; XVII, p. 291; XXII, p. 491. Report of the Director of the Mint, 1883, p. 158; 1884, p. 100; U. S. G. S. Bull. 540, pp. 109-110; U. S. G. S. Professional Paper 110, p. 116
Mormon Mine		16 S.	39 E.	Cerro Gordo Mines Co.	11.885	
Morning Glory Group	17,18,19,20	24 N.	3 E.	Clark Copper Co.	79.89	
Mountain Boy Group		22 S.	45 E.	Haskell Mining Company	55.043	
Mountain Spring Group	18	23 S.	41 E.	Alfred Giraud, Darwin	20.661	
Mountain Springs Canyon Placers		23 S.	42 E.	Curtis W. Shields, Jr., Beverly Hills	100	
Mountain Springs Canyon Mines	7,8,9,17,18	23 S.	41 E.	Mountain Spring Canyon Mines, Ltd., 907 Van Nuys Bldg., Los Angeles	400	R. XII, p. 136; XIII, p. 180
Mountain View Copper Group	20	24 N.	3 E.	Furnace Creek Extension Copper Company	97.15	
Mt. Tom		7 S.	30 E.	G. Crawford, Bishop	80	
Mt. Whitney				See Union Mines		
Nantasket		13 S.	36 E.	R. J. Daymon, et al., Independence	180	
Nemo Canyon Antimony Mines		19 S.	45 E.	Farlansee Wells, Death Valley Junction	120	
Nemo Chief Antimony Group		17 S.	45 E.	Ed. Attaway, Trona	80	
Neptune Mine (Loretta Mine)	16,17,20,21	8 S.	37 E.	Loretto Copper Co., New York City, N. Y.	102.71	R. XV, p. 73; XXII, p. 464
New Deal Group		23 S.	44 E.	Paul M. Koenecke, et al., Trona	120	
New Discovery & Gem Mines		20 S.	44 E.	Gem Mines, Inc., Bakersfield	100	R. XXVIII, pp. 364-366

New Enterprise Mine		16 S.	38 E.	Thomas Henning	20.55	
New Hope Group		22 S.	41 E.	H. R. Bradley, et al., Darwin	160	
New Moon Group		24 S.	31 E.	Ted Sterling, et al., Brown	140	
Ninety-Eight Quartz & Placer Mines		21 S.	40 E.	Leigh Moyle, Darwin	180	
Noonday & Grant Mines		20 N.	8 E.	Tecopa Cons. Mining Co., Dr. L. D. Godshall, 722 S. Oxford Ave., Los Angeles	205.741	R. XV, pp. 103-104; XVII, pp. 291-293; XXII, pp. 491-492; XXXIII, p. 267
North Star Group		21 N.	4 E.	C. O. Benson, Tecopa	160	
North Star Mine		15 S.	38 E.	D. E. Boelter, et al., Los Angeles	140	
Nu-Nah Group		10 S.	37 E.	Nu-Nah Mining Co., Big Pine	100	
O. B. J. Mine (Tyler Mine)				G. W. Tyler, et al., Trona	280	R. XV, p. 74; XXII, p. 465; XXVIII, pp. 371-372
Oasis Group		12 S.	37 E.	J. W. Wright, Big Pine	240	
Occident Mine		16 S.	38 E.	Geo. Jackson	10.32	
Ocean Queen Mine	16	21 S.	45 E.	Geo. S. Evans	19.79	
Ojala Group		20 N.	5 E.	F. A. Markley, Tecopa	100	
Old Mexican Mines		20 S.	40 E.	Mrs. Lucy Stanley, Darwin	120	
Olympic Mine		21 S.	41 E.	Joe Conner, Los Angeles	60	
Omega Group		16 S.	38 E. 39 E.	Cerro Gordo Mines Co.	98.443	
Ophir Mine		20 S.	40 E.	Walter Ross, et al.	100	
Oro Fino Mines	23	20 N.	8 E.	Tecopa Cons. Mining Co., Tecopa	41.322	
Oro Grande Placer		20 S.	40 E.	Sam S. Clark	20	
Oro Plato Mines		24 N.	3 E.	Furnace Creek Copper Co., Death Valley Junction	35.84	
Otso Group		20 S.	40 E.	L. Razner, Darwin	80	
Overlook Group		15 S.	41 E.	Cliff Palmer, Darwin	120	
Owens Lake View		14 S.	37 E.	Ellen Maysen, et al., Darwin	140	
Paddy Pride Mine		21 N.	5 E.	Paddy Pride Silver Mining Co., Shoshone	100	R. XVII, p. 294; XXII, pp. 493-494
Pagan Group		16 S.	39 E.	Cerro Gordo Mines Co.	339.713	
Palma Mine		16 S.	43 E.	Skiddo-Saddle Rock Mining Co., Trona	20.661	
Panamint Mine		21 S.	45 E.	A. D. Meyers, Los Angeles	360	R. XVII, pp. 280-281; XXII, pp. 495-500; XXVIII, pp. 361-364
Panamerica Group		24 S.	45 E.	Fred Gray and Wm. Hyder, Trona	80	
Panamint Group		19 S.	44 E.	Louis A. Kuehne, et al., Trona	600	
Paymaster		14 S.	37 E.	S. A. Banks, Independence	60	
Pennsylvania		16 S.	37 E.	J. D. Leary, Lone Pine	20	R. XVII, p. 293; XXII, p. 495
Pete Smith Mine		17 S.	38 E.	Wm. Skinner, et al., Lone Pine	120	R. XXII, pp. 495-496
Pierson Mining Co. Group of Mines		13 S.	36 E.	R. B. Whiteside, Duluth, Minn.	400	R. XXII, p. 496
Pine Creek Tungsten		7 S.	29 E.	U. S. Vanadium Corp., 30 E. 42d St., New York. Bishop	245	R. XVII, pp. 301-302; XXII, pp. 511-512
Pine Tree Group		22 S.	45 E.	Harvey Searing, Trona	120	R. XXII, p. 496
Pioneer Mines		19 S.	45 E.	C. E. Babcock, Darwin	40	
Pittsburg Group	36, 1	21 N. 20 N.	5 E.	J. H. Riddle, et al.	41.162	
Plummer Group		21 S.	7 E.	Albert W. Plummer, Shoshone	280	
Poco Pronto Mines		24 N.	3 E.	Furnace Valley Copper Co.	38.28	
Polita Mine		7 S.	34 E.	Polita Gold Mining Co., Bishop	20.65	R. XII, p. 139; XIII, p. 183
Primus Mine	30	22 S.	43 E.	Geo. Johnson, Jr., Trona	11.19	R. XV, pp. 105-106; XXII, p. 496
Promontory		19 S.	40 E.	Darwin Development Co., N. Y.		
Pumpkin Group		29 N.	3 E.	Pumpkin Gold Mining Co.	36.75	
Radcliff Mine		22 S.	46 E.	Radcliff Cons. Gold Mining Company, Trona	137.487	R. XV, p. 83; XXII, p. 472; XXVIII, pp. 373-376
Rainbow Mine	10	20 N.	8 E.	Tecopa Cons. Mining Co., Tecopa	25.60	

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Rainbow Group of Mines	12, 21, 22	22 N.	7 E.	A. W. Plummer, 2062 Glencoe Way, Hollywood	500	
Rattler Group	20, 21	24 N.	3 E.	Furnace Creek Extension Copper Company	51.38	
Raven Mine		15 S.	40 E.	Archie Farrington Estate, Bishop	120	
Red Boy Group	35, 36, 1, 2	24 N. 23 N.	3 E.	Greenwater Red Boy Copper Co.	104.32	R. XV, p. 106; XVII, p. 293; XXII, p. 496
Red Hill Group		20 S.	39 E.	Walter Palmer, Darwin	400	
Red Mexican Group		20 S.	39 E.	M. D. Early, et al., Lancaster	40	
Red Rock Group		21 S.	40 E.	Fred J. Wilbur, Darwin	120	
Red Top Group		21 S.	39 E.	Harry E. Woodson, et al., Darwin	160	
Red Wing		22 N.	7 E.	R. J. Fairbanks, Shoshone	20	R. XV, p. 106; XXII, pp. 497
Reed Flat Mine		7 S.	34 E.	Judge J. O. Ray, Beatty, Nevada	165	R. XXII, p. 497
Reno Group		19 S.	40 E.	Charles Richardson, Darwin	30.98	
Republic Group	5	13 S.	36 E.	H. B. Whiteside	94.677	
Reward Mine				See Brown Monster		
Rex Montis Mine		13 S.	33 E.	Howard Mears, Independence	84.12	
Richardson Group	13,24,18,19	19 S.	40 E. 41 E.	Chas. Richardson, Darwin	127.211	
Ridge Lookout Group		13 S.	34 E.	Geo. V. Parker, Independence	520	
Rio Tinto Groupe	24	19 S.	40 E.	Joseph L. Giroux, Darwin	166.572	
Rob Roy Mines (Ibex)	35, 2	20 N. 19 N.	5 E.	Ibex Springs Mining Company, Shoshone	73.458	R. XV, pp. 96-97
Rock Point Group (Cardinal)	19,20,29,30	8 S.	31 E.	Cardinal Gold Mining Co.	252.832	R. XV, p. 85; XVII, pp. 281-292; XXII, p. 474
Rosario Group	31, 32	28 N.	3 E.	Rosario Gold Mining Co.	117.243	
Round Valley Tungsten Mine		6 S.	31 E.	Pacific Tungsten Corporation, 5514 Wilshire Blvd., Los Angeles	160	R. XVII, pp. 302-303; XXII, p. 512. U. S. G. S. Bull. 640b
Round Valley Mines		7 S.	31 E.	Al Stevens, et al., Bishop	100	R. XVII, pp. 302-303; XXII, p. 512. U. S. G. S. Bull. 640b
Royal Mine				See Cerro Gordo Extension Mine		R. XV, p. 106; XVII, p. 294; XXII, p. 497-498
Ruth Mine		23 S.	42 E.	F. L. Austin, Trona	260	
Saddle Rock Mine		16 S.	43 E.	Skiddo Saddle Rock Mining Co.	66.22	
San Benito Mine		16 S.	38 E.	Levi Lasky, Keeler	19.28	
San Pedro		9 S.	37 E.	W. A. Coulter, San Pedro	160	R. XXII, p. 498
Santa Ana		19 S.	40 E.	Alex Ruona, Darwin	60	
Santa Maria		16 S.	38 E.	Santa Maria Silver Lead Mining Co.	5.48	
Santa Rosa	26, 35	17 S.	39 E.	Santa Rosa Mining Co., 357 S. Hill St., Los Angeles	113.62	R. XV, p. 108; XVII, p. 294; XXII, pp. 498-499
Saratoga Copper Mines	1	23 N.	3 E.	Greenwater-Saratoga Copper Co.	100	
Scotchman Group	13	22 S.	45 E.	Ballarat Gold Mining Co., Trona	66	
Senator Mine	32, 5	11 S. 12 S.	35 E.	R. C. Chambers	20.58	
Seymore Mine	11, 14	21 S.	45 E.	Geo. M. Pinney, et al.	21	
Shannon Creek Tungsten (Buckshot)		8 S.	33 E.	H. R. Bartel, Big Pine	20	
Silver Button & Shamrock Mines				See Darwin-Keystone Mine		R. XXII, pp. 499-500
Silver Dome Group		7 S.	36 E.	M. E. Holman, et al., Big Pine	280	R. XVII, p. 289; XXII, pp. 488-489

Silver Peak Hemlock				See Panamint Mines		
Silver Reef Mine				See Ventura Mine		R. XV, p. 110; XVII, p. 295; XXII, p. 503; U. S. G. S. Professional Paper 110, p. 117
Silver Rule Mine		19 N.	10 E.	Pacific Lead-Silver Mining Co., Los Angeles	240	R. XV, p. 104; XVII, pp. 365-366
Silver Spoon Mine Group		19 S.	40 E.	Theo Peterson, Darwin	100	R. XXII, pp. 500-501
Skidoo (Silver Ball) Mine		17 S.	44 E.	Judge W. B. Gray, Trona	240	R. XV, pp. 83-84; XXII, p. 473
Slate Range Mine				See California Queen of Gold Bottom Mine		R. XXII, p. 501
Sleeping Beauty Group		6 S.	36 E.	Harry Miller, et al., Big Pine	180	
Southern Homestead Group		23 S.	44 E.	Harry E. Broggs, Trona	200	
Southwest Mine	13	19 S.	40 E.	David C. Lang, Darwin	17	
Speculator Group	26, 27, 34, 35	24 N.	3 E.	United Greenwater Copper Co.	227	
Squash Group		29 N.	3 E.	J. P. Nelson, et al.	39.38	
St. George (Merry Christmas) Mine		20 S.	42 E.	J. C. Cress, et al. Leased to Chas. F. Hamilton, 1541 S. St. Andrews Place, Los Angeles	120	R. XV, p. 82; XXII, p. 471
Standby Group		15 S.	36 E.	Robt. Lawrence, et al., Lone Pine	480	
Standard		22 S.	45 E.	Frank Groch, Trona	240	
Standard Group		19 S.	40 E.	Alex Ruona, Darwin	380	
Star Mine		21 S.	45 E.	Star Silver Mining Co.	20.28	
Star of the West Mine	4, 5, 8, 9	24 S.	31 E.	Star of the West Mining Co., 320 E. Jefferson, Los Angeles	121.749	
State Line	28, 33	29 N.	3 E.	Hayseed Mining Co.	19.32	
State Line Mines		26 N.	5 E.	Oliver C. Edwards, Jr., Beatty, Nevada	160	
Sterling Mine		20 S.	42 E.	Sterling Mining Co., Trona	120	
Stewart's Wonder Mine (Panamint Mine)	10	21 S.	45 E.	A. D. Meyers, Los Angeles	25.661	R. XVII, pp. 280-281; XXII, pp. 495-500, XXVIII, p. 363
Stockwell Mine		23 S.	44 E.	Stockwell Gold Mining Co., Los Angeles	130	
Summit No. 2 Mine		16 S.	38 E.	A. R. Conklin, et al.	18.34	
Sunrise View Mines		15 S.	36 E.	A. C. Zell, Lone Pine	480	
Syndicate Mine	14	20 N.	8 E.	Los Angeles Mining & Smelting Company	15.25	
Telescope Group. (See Reward Mine)	3	14 S.	36 E.	Reward Gold Mines Co.	64.215	
Telescope View Group		18 S.	45 E.	O. F. Dearborn, et al, Trona	80	
The Sterling Mine		20 S.	42 E.	M. A. Collins, et al., Trona	120	
The Wanderer Mines		23 S.	42 E.	D. W. Whipple, Trona	140	
Tip Top Mine		22 S.	45 E.	I. J. Sopp, et al., Trona	320	
Tom Casey Mine		13 S.	37 E.	Tom Casey, Lone Pine	120	
Topah Group		21 N.	1 E.	Carl Mengel, Trona	260	
Treasure Mine		21 N.	1 E.	Death Valley Mining Co.	45.93	
Treasure Hill Mine		17 S.	45 E.	L. E. Mendelman, et al., Los Angeles	240	
Tucki Mine		17 S.	45 E.	Ed Attaway, et al., Darwin	120	
Ubehebe Mine		14 S.	40 E.	Archie Farrington Estate, Bishop	240	R. XI, p. 109; XVII, p. 294; XXII, p. 501
Ulida Mines		14 S.	41 E.	P. E. Day, Darwin	240	
Uncle Sam Mine (See Ophir Mine)	24	24 S.	43 E.	Engineer's Exploration Corp., Trona	61.983	
Union Cons. Group	5	13 S.	36 E.	Union Cons. Mining Co.	35.115	R. XXII, p. 496
Union Mines	14	14 S.	36 E.	Monte Carlo Mines, Inc., Los Angeles	140	R. XV, p. 80; XXII, pp. 501-503
Utacala Mine		19 S.	42 E.	Albert Miller, Keeler	240	R. XVII, pp. 294-295; XXII, p. 503
Ventura Mine		16 S.	38 E.	Thomas Henning, et al., Keeler	20.63	
Ventura Mine (Silver Reef)		16 S.	38 E.	Mrs. Chas. Bangoe, Keeler	340	R. XV, p. 110; XVII, p. 295; XXII, p. 503; U. S. G. S. Professional Paper No. 110, p. 117
Vermont Group (See Keane Wonder Mine)	1, 12, 16	15 S. 29 N.	46 E. 1 E.	Keane Wonder Mining Co.	41.32	
Vernon		24 S.	44 E.	Stockwell Gold Mining Corp., Trona	205	

METAL MINING CLAIMS, INYO COUNTY—Continued

Name of mine	Location			Last owner's or operator's name and address	Area, acres	Bibliography
	Sec.	Twp.	Range			
Victor Group	3, 9, 10, 11	8 S.	37 E.	C. E. Cady, et al.	243.085	
Virginia Group		13 S.	33 E.	Virginia Cons. Mining Company	26.63	
Vin Blanc Mine		20 S.	40 E.	Geo. C. Terry, et al., Independence	20.00	
Vulcan Group		22 S.	42 E.	F. W. Chappell, Darwin	120	
War Eagle Mine	14, 15, 22, 23	20 N.	8 E.	Tecopa Cons. Mining Co.	180	R. XXII, pp. 503-504
Waucoba Tungsten Mine		11 S.	37 E.	Stuart Bedell, et al., Big Pine	240	
Westfalia Group	24	23 S.	42 E.	Peter B. Mathiason	61.09	
Westgard Mine (Chalmers)		7 S.	35 E.	Westgard Cons. Mining Co., Tonopah, Nevada	280	R. XVII, p. 284; XXII, p. 482
West Point Group		23 S.	42 E.	Geo. G. Widman, Darwin	420	
Westward Ho Group		21 N.	3 E.	Lyle W. Rucker, Shoshone	520	
White Eagle Group		22 S.	44 E.	C. Ferge, Trona	80	
White King Group		21 N.	7 E.	John and Silvia Prato, Shoshone	80	
White Star Group		20 S.	38 E.	J. M. Henry, Olancha	140	
Wild Rose Antimony Mines		19 S.	45 E.	T. F. Pierson, et al., Los Angeles	220	R. XII, p. 21; XV, p. 60; XXII, p. 462
Williams & Johnson Antimony Mine		19 S.	45 E.	Ralph Williams & Geo. Johnson	20	R. XV, p. 62; XXII, pp. 462-463
Wilshire Bishop Creek Mine				See Cardinal Gold Mining Co.		R. XV, p. 85; XVII, p. 281-282; XXII, p. 474
Winnie Mae Group		22 S.	44 E.	Ralph A. Stuckley, et al., Trona	200	
World Beater		22 S.	45 E.	Ballarat Mining Co., Trona	280	R. XXVIII, p. 376
Wonder Mine		19 S.	41 E.	Richard Wallace, Darwin	80	R. XXII, p. 465
Wyoming Mine	10, 11, 14, 15	21 S.	45 E.	A. D. Myers, Los Angeles	25.661	R. XXII, p. 495; XXVIII, pp. 363-364
Yankee Girl Mine		13 S.	36 E.	Sierra Syndicate, Independence	120	
Ygnacio (Ignacio)		16 S.	38 E.	Cerro Gordo Mines Co., San Jose	3.66	R. XV, pp. 97-98; XVII, p. 287; XXII, p. 485; R. W. Raymond, Mineral Resources West of the Rocky Mountains, 1780, p. 17
Yucca Mine		20 S.	40 E.	L. D. Owen, Darwin	20	R. XV, p. 85; XXII, p. 474

NONMETALLIC MINERALS

Inyo County has a great variety of commercial minerals which are used locally, and large tonnages of both industrial and structural materials are shipped out of the county to manufacturing centers along the Pacific Coast. Deposits of barytes, bentonite, clay, dolomite, limestone, marble, pumice, sulphur, and talc are distributed throughout the county and transportation and other facilities are gradually being extended so that the growing demand may be met. Since Report XXII of the State Mineralogist was published, a number of new talc deposits were developed and put under production. An important feature has been the development of the sulphur deposits in the Last Chance Range in the northeastern section of the county near the Nevada state line. A considerable tonnage of high-grade sulphur, both crude and refined, was shipped to Los Angeles from these deposits in 1936 and 1937. Another feature was the development of the pumice deposits in the Coso Range and the White Mountains near Laws.

BARITE

Gunter Canyon Barite Deposit. It is located in Gunter Canyon on the west flank of the White Mountains, 6 miles northeast of Laws; elevation, 6300 ft.

A series of parallel veins of barite occurs in the Cambrian schists and slates. A considerable tonnage was shipped from this deposit in 1928 and 1929. The barite is gray to white in color and is reported to carry 94% barium sulphate with specific gravity of 4.2. Idle.

Bibl.: State Mineralogist's Report XXII, pp. 512-513.

Poso Baryta Deposit. It comprises 4 claims and a millsite, located in Sec. 23, and 24, T. 24 S., R. 36 E., M. D. M., on the eastern slope of the Sierra Nevada, at an elevation of 7500 ft. in Tulare County, 15 miles west of Linnie, a station on the Southern Pacific Railroad. Although the property is located in Tulare County, it will be described in this report, as it is near to the boundary line of Inyo and Tulare counties, and all shipments made from the deposit are from Linnie in Inyo County. Owner is *Western Barium Corporation,* 1643 Russ Building, San Francisco; R. A. Fredricks, president and general manager.

Three parallel veins occur along a shear zone in quartz-diorite. In the shear zone along the veins there is schist with a dolomite outcrop on the footwall side of the vein. The vein outcrops show widths varying from 10 ft. to 70 ft., the average being about 20 ft. These outcrops can be traced continuously for over 4000 ft. The strike of the veins is N. 20° W., dip 50° to 60° SW. The width of the vein exposed in the main working tunnel is 12 ft.

Development consists of a tunnel, driven north 200 ft. with 75 ft. of backs. The tunnel is 400 ft. below the highest point on the hill. The analysis of the barite is stated to be 80% to 90% barium sulphate, with 8% to 10% silica, and lime content, 1.5%; specific gravity of 4 to 4.2. The barite is white in color and is of the soft, crystalline variety. The company has under construction a barium products plant

at Rosamond, Kern County. Ten men are employed on plant construction and 6 men at the mine.

Warm Springs Canyon Barite Deposit. It comprises 6 claims located on the eastern slope of the Panamint Range, in Warm Springs Canyon, 45 miles west of Shoshone, a station on the Tonopah and Tidewater Railroad; elevation, 3000 ft.; owners, Harry P. Gower and Owen Montgomery, of Death Valley Junction, California.

The outcrop is reported to be 6 ft to 8 ft. wide and has been exposed by open cuts along the surface for some distance. Analyses of the ore show the barite to carry 90% barium sulphate, with a specific gravity of 4.2. The barite is white in color. This is a new discovery, located in the latter part of 1937. Three men are employed on development.

DOLOMITE and MARBLE

The principal mountain ranges east of the Sierra Nevada range are made up in places of dolomitic limestone. The only commercial deposits being developed at the present time are those of the Inyo Marble Co., of Los Angeles, Calif. These deposits occur on the southwestern flank of the Inyo Range and extend for about 6 miles northeastward from Swansea Station. Some tonnage of dolomite is shipped to the soda plant of the Pacific Alkali Co. at Bartlett on Owens Lake. A considerable amount is shipped to Los Angeles for flux for steel plants and for terrazzo, art stone, stucco aggregates and poultry grits. The marble outcroppings along the base of this range show a thickness of at least 500 ft. The beds are tilted at a high angle, dipping to northeast into the mountain. The marble is dolomite, fine-grained and hard. Three varieties of marble are found in this deposit; a pure white, a yellow, and a variegated marble of white ground-mass. At the time the deposit was visited no marble was being quarried on account of the lack of demand on the Pacific Coast.

Owner, *Inyo Marble Co.;* D. H. Dunn, president and manager; offices, 359 North Avenue 22, Los Angeles.

Bibl.: State Mineralogist's Reports X, p. 215; XII, p. 392; XIII, p. 628; XV, p. 111; XVII, p. 295; XXII, pp. 515-516; Bull. 38, pp. 99, 100.

MARBLE ONYX

Death Valley Onyx Deposit is in Revenue Canyon on the east slope of the Panamint Mountains about 12 miles northwest of Ballarat; owner, *Artcraft Onyx Co.,* E. N. Degner, president; H. C. Degner, secretary; 2923 Kenwood Ave., Los Angeles.

This deposit occurs on the top and west slope of a small knoll, resting on crystalline limestone. It occurs in bands varying from 6 in. to about 2 ft. thick, the total thickness being approximately 6 ft. Colors are red, cream and brown.

It is developed by open cuts. One on top of the hill is about 25 ft. long, 20 ft. wide, with a maximum depth of about 8 ft. It is also opened up on the slope of the hill about 300 ft. east where the total thickness appears to be about 4 ft. At this point the red color predominates.

Worked intermittently.

FELDSPAR

Nine-Mile Canyon Feldspar Deposit. It comprises 3 claims located in T. 24 S., R. 37 E., S. B. B. M., 5 miles west of Linnie, a siding on the Owens Valley Branch of the Southern Pacific Railroad; elevation, 4000 ft.; owner, E. G. Washmuth, Inyokern, California.

Two massive outcrops of silica and feldspar occur in the granite on the ridge west of Nine-Mile Canyon. The lower outcrop is about 250 ft. in elevation above the floor of the canyon. This outcrop is 40 ft. in width and 100 ft. in length.

Development is by a crosscut tunnel driven south 50 ft. in granite. In the face of the tunnel there is exposed 6 ft. of feldspar and 8 ft. of silica. A raise has been put up on the feldspar to the surface, and the material is mined from a glory hole. The feldspar mined is brown to pink in color. About 250 ft. south of the glory hole, and about 300 ft. in elevation above these workings, is a massive outcrop of feldspar and silica which is 150 ft. wide and 200 ft. in length; developed by an open cut.

Analysis:	Silica (SiO_2)	63.82%
	Aluminum oxide (Al_2O_3)	18.54%
	Ferric oxide (Fe_2O_3)	0.11%
	Magnesium oxide (MgO)	0.61%
	Potassium oxide (K_2O)	13.33%
	Sodium oxide (Na_2O)	1.35%
	Calcium oxide (CaO)	Trace
	Loss in ignition	0.04%

Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 415-416.

White King Feldspar Deposit. It comprises 6 claims located in Sec. 31 and 32, T. 23 S., R. 37 E., 12 miles west of Linnie, a siding on the Owens Valley Branch of the Southern Pacific Railroad; elevation, 6500 ft.; owner, H. W. Wright, South Pasadena, California.

Massive outcrops of feldspar occur on five small, round hills in a mountain valley in the Sierras. These outcrops have a width of 50 ft. and indicate that a large tonnage of feldspar can be developed. The feldspar is white in color and free of iron. A number of cars were shipped to Los Angeles in 1933.

Analysis of orthoclase feldspar by John E. Skelton, chemist of the Natural Soda Products Co., Keeler, Calif.:

Silica (SiO_2)	64.90%
Ferric oxide (Fe_2O_3)	Trace
Aluminum oxide (Al_2O_3)	18.95%
Calcium oxide (CaO)	0.84%
Magnesium oxide (MgO)	Trace
Sodium oxide (Na_2O)	2.92%
Potassium oxide (K_2O)	12.60%
	100.21%

A fusion test showed sample fused to a white, opaque, glassy mass. Idle.

FLUORITE

Warm Springs Canyon Deposit, comprising 4 claims, is in Warm Springs Canyon, on the east slope of the Panamint Mountains, 70 miles southwest of Death Valley Junction; owner, Owen Montgomery, Death Valley, Calif.

The deposit has been traced for several hundred feet along the surface by open cuts and about 100 ft. of tunnel work.

Idle except for assessment work.

FULLERS EARTH (BENTONITE)

Fullers earth includes many kinds of unctuous clays. It is usually soft, friable, earthy, white and gray to dark green in color and some varieties disintegrate in water. The principal production in Inyo County of the clay known as bentonite and "shoshonite," a colloidal clay, has been from Shoshone, a station on the Tonopah & Tidewater Railroad, and from a deposit located in the Coso Range east of Olancha. The most extensive beds are those along the Amargosa River in the vicinity of Tecopa, Shoshone, and Ash Meadows, extending across the state line into Nye County, Nevada. Only a small amount of material is shipped from Shoshone, as the principal production at present is from the Ash Meadows deposits in Nye County, Nevada. The bentonite from here is ground in the grinding plant of the Pacific Coast Borax Company at Death Valley Junction.

Calearth Fullers Earth Deposit. It comprises 1120 acres located in Sec. 13, 14, 23 and 24, T. 18 S., R. 38 E., M. D. M., in the foothills at the north end of the Coso Range, 12 miles east of Olancha, a station on the Owens Valley Branch of the Southern Pacific Railroad; elevation, 4500 ft.; owner, Calearth Corporation; W. R. Cantley, president, Los Angeles, California. The *Filtrol Company*, 315 W. 5th Street, Los Angeles, recently purchased 160 acres.

The fullers earth occurs in a bed, which strikes N. 85° E., dipping 10° N. The bed, covered by a flow of rhyolite, has a thickness of from 15 ft. to 50 ft. The outcrop is traceable for one mile in a north-south direction and 3500 ft. in an east-west direction. The material is mined by stripping and benching, and is being shipped to the Olancha Mineral Products Company's grinding plant at 6300 E. Slauson Ave., Los Angeles, also to the Filtrol Company's plant in Los Angeles. Four to 6 men are employed.

Filtrol Company's Deposit. It is situated 2 miles northwest of Shoshone. Holdings comprise 280 acres; owner, Filtrol Company, Los Angeles. Idle.

Bibl.: State Mineralogist's Reports XVIII, p. 298; XXII, p. 514.

Shoshone Bentonite Deposit. This deposit is located one-quarter of a mile west of Shoshone. Holdings comprise 320 acres; owner, *Associated Oil Company,* of San Francisco, California.

Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 297, 298; XXII, p. 514; Min. Jour. Press, Vol. 121, pp. 837-842, May 22, 1926.

PUMICE and VOLCANIC ASH

Deposits of pumice occur in the Coso Range, 6 miles east of Coso Junction, a station on the Southern Pacific Railroad, and also northeast of Laws, on the west slope of the White Mountains, near the Mono

County line. Extensive beds of volcanic ash occur in the Tertiary sediments of the Amargosa Valley near Shoshone and also south and west of Death Valley Junction.

Coso Mountain Pumice Deposit. The deposit is located on the west slope of the Coso Range, 6 miles east of Coso Junction. Holdings comprise 320 acres; owners, H. P. Thelan, of Coso Junction, and Walter W. Brown, Balboa Beach, California.

Bibl.: State Mineralogist's Report XXII, p. 521.

Hidecker Pumice Deposit (formerly Hunter Canyon). It is located in Hunter Canyon, 3½ miles northeast of Laws, on the west slope of the White Mountains. Holdings comprise 20 acres; elevation, 5500 ft.; owners, Wm. Rea and Tom Gracy, of Bishop.

The pumice is exposed over the entire 20 acres, with only a small amount of overburden. It is white in color, and very fine, the maximum size being 2 inches. A screening plant has been erected and several hundred tons taken from an open cut which is 100 ft. long, 20 ft. wide and 8 ft. deep. Idle.

Little Lake Pumice Deposit. It comprises 4 claims totaling 160 acres, situated in Coso Range of mountains, in Sec. 35, T. 21 S., R. 38 E., 5 miles east of Sykes, a siding on the Southern Pacific Railroad; owners, Little Lake Pumice Co., 1204 South Monterey St., Alhambra, California; W. A. Ried, president; W. H. Faust, manager.

An open cut has exposed a bed of white pumice 50 ft. thick. The pumice varies in lumps up to walnut size.

The material is hauled by trucks to crushing, screening plant at Sykes Siding. Pumice is dumped from trucks into hopper, from which it goes to cylindrical drier 43 in. in diameter and 30 ft. long, heated by crude oil. The dried product is elevated to trommel 3 ft. in diameter and 10 ft. long, with 30 mesh screen; over-size from trommel to set of rolls 14 by 26 in., driven by 20-h.p. gas engine. Plant has a capacity of 4 tons per hour. Six men are employed.

Pumice Products Company's Deposit. It comprises four 160-acre placer claims, totaling 640 acres, situated in T. 22 S., R. 40 E., on the south slope of Volcanic Butte, in the Coso Range, 24 miles by road northeast of Brown, a station on the Southern Pacific Railroad; elevation 4000 ft.; owner, Lee Early, Bishop, California. The property is under lease to Pumice Products Co., Paul E. Splane, 417 S. Hill St., Los Angeles.

On the White Pumice Claim, a bed of white pumice is exposed which strikes N. 40° W., dips 40° SW. and is capped by 6 ft. to 8 ft. of basalt. The bed of pumice is 50 ft. thick.

On the Tired Boy Claim which is located about one mile northwest of White Pumice Claim, a bed of pumice has been exposed on the surface for about 2000 ft. in length, with an average thickness of 30 ft. It is capped with basalt. The strike of the bed of pumice is N. 30° E., dip 30°. It is developed by open-cuts and incline shaft 40 ft. deep. Equipment consists of hoist and trucks.

The ore is treated in the company's plant in Van Nuys. Products produced: Pumice aggregate ¾-in. to 8-mesh; acoustic plaster material

minus 10-mesh plus 20-mesh, minus 12-mesh plus 30-mesh; polish material 150-mesh to 400-mesh. Four men are employed.

Bibl.: State Mineralogist's Report XXII, p. 521.

Shoshone Volcanic Ash Deposit. The deposit is located one-quarter of a mile west of Shoshone. Holdings comprise 480 acres; owner, Charles Brown, Shoshone.

A bed of tuff, 8 ft. to 10 ft. thick, is deposited in the Pleistocene sediments of the Amargosa Valley. The bed of volcanic ash is covered with an overburden of sand, gravel and clay, 3 ft. to 4 ft. thick. An open cut on the deposit is 200 ft. wide by 300 ft. in length. The method of working consists of first stripping off the overburden, then loading material into trucks. Four hundred tons were shipped in 1937 to the Western Talc Company's grinding plant in Los Angeles, for the West Coast Soap Company, of Los Angeles. Two to 4 men are employed.

Bibl.: State Mineralogist's Report XXII, p. 521.

The Sierra Minerals Inc., of Los Angeles, are operating a pumice deposit, located about 4 miles southeast of Olancha, T. 20 S., R. 37 E. Holdings consist of 3 claims, owned by L. T. Lynn, Homer Chase and John D. Calloway, of Olancha.

The pumice bed is about 20 ft. thick and is mined by benching. Holes are drilled with hand augers and the blasted material loaded into wheelbarrows and dumped into the ore bin. From the crude ore bin the pumice is fed to a Weaver jaw and hammer type crusher, driven by a 14-hp. Fairbanks-Morse gasoline engine, thence to a cylindrical drier, 3 ft. in diameter and 21 ft. long, heated by crude oil. The dried product goes to 2 trommels, 3 ft. in diameter and 10 ft. long with 30-mesh screens. The screened product is elevated to a loading bin by a bucket elevator. The screens and elevator are driven by a $7\frac{1}{2}$-hp. Fairbanks-Morse gas engine. Production is about 15 tons per day. Six men are employed.

Tripoli Volcanic Ash Deposit. It comprises 4 claims, located 6 miles south of Death Valley Junction and one mile west of the Tonopah and Tidewater Railroad; owners, Patrick Miles and William Maher, of Death Valley Junction.

It is a bedded deposit of volcanic ash, 20 ft. to 30 ft. thick, covered by a basalt flow. The exposures along the bed can be followed for 3000 ft. The strike is east and west. A large commercial tonnage can be developed. Idle.

Virginia Volcanic Ash Deposit (Glendenning). It is located 2 miles south of Shoshone in Sec. 31 and 32, T. 22 N., R. 7 E., M. D. M., on the west side of Amargosa River; elevation, 1800 ft.; Virginia Group of 8 claims; owner, R. W. Glendenning, Los Angeles. Idle

Bibl.: State Mineralogist's Report XXII, pp. 521-522.

SLATE

A deposit of slate is located on the west slope of the Inyo Range, 4 miles northeast of Keeler. Holdings comprise seventeen 160-acre

placer claims; owners, R. B. McIlroy and Sons, of Keeler, California; W. B. Pinney, 112 W. Jefferson St., Los Angeles, distributing agent.

Beds of black, gray and red slate strike N. 30° W., and dip 70° W. The red slate is quarried by hand and shipped to grinding plants to be ground for roof granules. Some material is used for flagstones.

SULPHUR

The sulphur deposits of the Last Chance Range occur in sedimentary beds with gypsum and limestone. The sulphur is probably formed by the reduction of gypsum by organic matter, and occurs in lenses along bedding planes of limestone which have been tilted, dipping steeply to east, and massive bedded-deposits 16 ft. to 30 ft. thick,

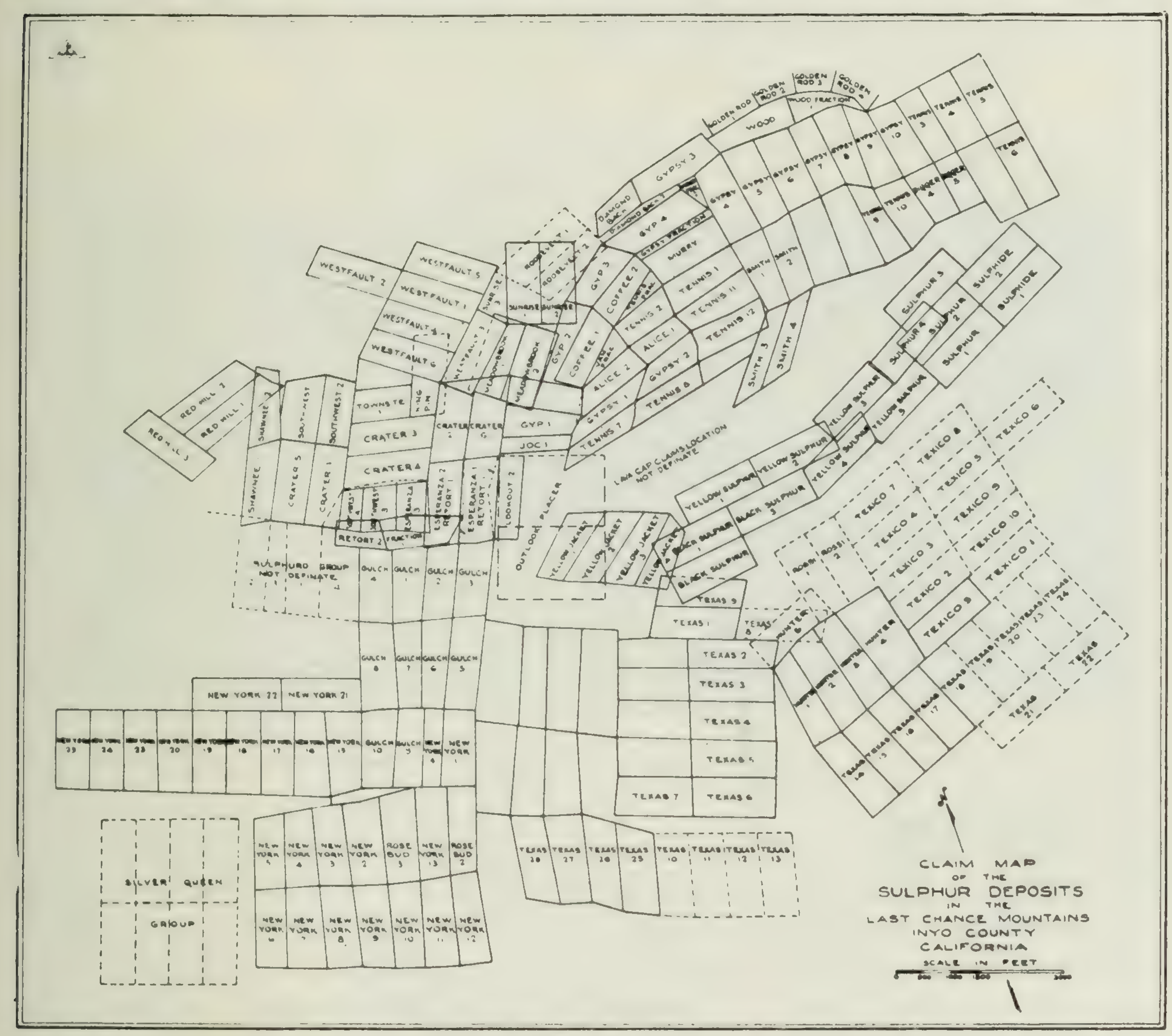


FIG. 12.

overlain with beds of gypsum and limestone from 2 ft. to 15 ft. in thickness. The sulphur content varies from 30% to 80%.

Sulphur was first discovered in the Last Chance Range in 1917 and since that date, about 200 claims have been located in the area. The mineralized area is about 3 miles in length by one mile in width, with a general north and south strike. The principal deposits so far discovered are in T. 8 S., R. 39 E., M. D. M. The first active development was on the Crater Group of Claims in June, 1929, by the *Pacific Sulphur Co.*, of New York. Since that date the Crater Group has been actively worked by different companies and a considerable tonnage of high-grade sulphur shipped to Los Angeles (see Fig. 12).

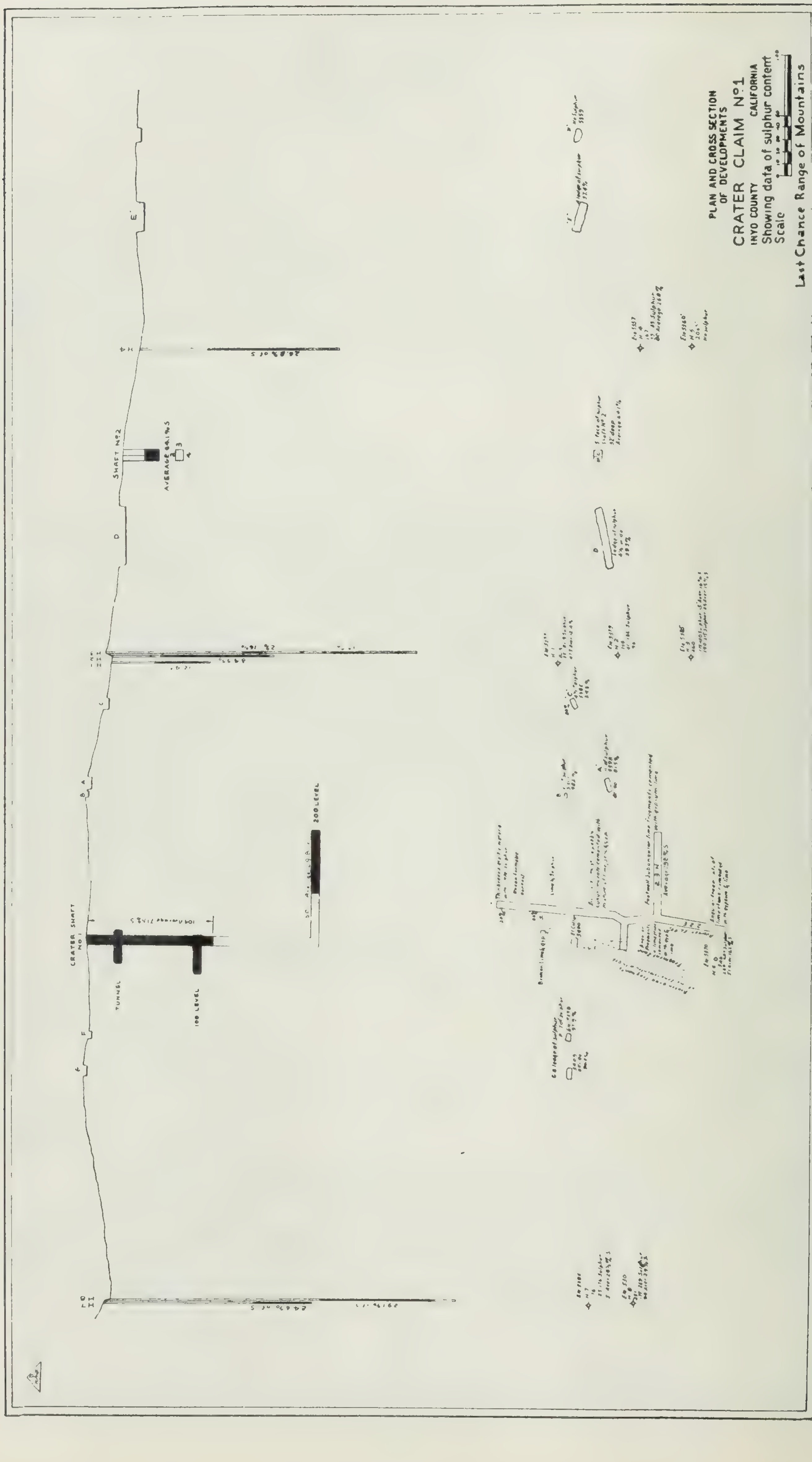

PLAN AND CROSS SECTION
OF DEVELOPMENTS
CRATER CLAIM No 1
INYO COUNTY
CALIFORNIA
Showing data of sulphur content
Scale
Last Chance Range of Mountains
CRATER SHAFT NO 1
TUNNEL
100 LEVEL
200 LEVEL
SHAFT NO 2

FIG. 13.

Crater Sulphur Mine. It comprises 7 claims, located in Sec. 16 and 17, T. 8 S., R. 39 E., M. D. M., 64 miles by road east of Zurich, a station on the Owens Valley Branch of the Southern Pacific Railroad, and 27 miles south of Oasis; elevation 5380 ft.; owners, F. B. Mechling, Alexander Bonthrone, Paradise, Butte Co., Calif., and Frank Hicks, Big Pine, Calif. Under lease to *Western Mining Co.,* J. C. Baldwin, president and general manager; C. W. Van Alstine, general superintendent; A. C. Palmer, mine superintendent. Sales agent: Western Sulphur Products, Inc., 1427 E. Fourth St., Los Angeles. The property was operated by the *Pacific Sulphur Co.,* of New York, from June, 1929, to December, 1930.

On Crater No. 1 Claim, this company put down 8 drill holes to depths of 80 ft. to 300 ft.; also sunk a 2-compartment shaft on inclination of 68° to a depth of 200 ft., with levels at 100 ft. and 200 ft. (see Fig. 13).

PHOTO. 17. Open cut and portal—Crater Sulphur Mine, Last Chance Range of Mountains, Inyo County.

The property was operated under lease by W. H. Sanger and Morris Albertoli, of Big Pine, from September, 1932, to 1934, when it was acquired under lease by the *Western Sulphur Industries, Inc.,* of Los Angeles. This company shipped some 4500 tons of 96% sulphur to Stauffer Chemical Co., of Los Angeles.

In August, 1936, the *Sulphur Diggers, Inc.,* Sidney Wood, Jr., president, New York City, acquired the property under lease and operated the property until September, 1937. During the period of operations, the Sulphur Diggers, Inc. installed retorts on the property and also a 60-ton vertical retort at Zurich, the latter operating only a short time before operations were suspended. The Sulphur Diggers, Inc., shipped 5000 tons of crude ore, running 96% sulphur, and refined sulphur running 99.5% was shipped to Los Angeles.

The Western Mining Co. acquired the property in January, 1938, and started construction of new retort which was completed in May, 1938. Present mining operations are confined to the open pit on

Crater No. 6 Claim. The open pit has been excavated for 200 feet in an east-west direction by 110 ft. north-south course. Three beds of sulphur have been mined in this open pit. Thickness of the different beds was from 8 ft. to 20 ft. The beds of sulphur strike north and south and dip about 12° W. The filling between beds is gypsum and lime.

PHOTO. 18. 100-ton Retort, Crater Sulphur Mine, Western Mining Co., Last Chance Range of Mountains, Inyo County. (Later) This plant was destroyed by fire.

From the open-pit floor, the main entry is driven north 110 ft., with galleries driven 50 ft. east and west exposing a bed of sulphur 16 ft. to 20 ft. thick. A slope shaft has been sunk on an inclination of 12° to a depth of 200 ft. to the west, with galleries driven north and south 100 ft. The capping over the sulphur bed is 16 ft. to 20 ft. thick of gypsum, lime and soil. It is reported 10,000 tons of sulphur are developed which will average 80% sulphur. At south end of open pit a shaft has been sunk to a depth of 50 ft. developing another bed of sulphur 27 ft. thick.

They are at present mining about 100 tons per day. Ore mined from different underground workings goes to slope shaft where it is hoisted in one-ton cars by 15-hp. hoist to ore bins having a capacity of 100 tons. From ore bins, it is loaded into trucks and hauled to coarse-ore bin above refinery. The refinery has a capacity of 100 tons of crude sulphur. The refinery consists of two circular horizontal retorts. Each retort has a capacity of three 2-ton steel cars. Steam for retorts is furnished by 125-hp. boiler. Refined sulphur produced runs 99.8%. Storage vats have a capacity of 600 tons of refined sulphur. Water for operation of plant is secured at Oasis and is hauled in two tank trucks having a capacity of 2800 gallons each. The amount of water required to operate refinery is 3250 gallons per 24 hours.

Fifteen employed in mine and 15 men in refinery. The total number of men employed is 50.

Bibl.: State Mineralogist's Reports XVII, p. 300; XXII, p. 523.

Fraction and *Southwest Sulphur Group of Mines.* It comprises one claim known as Fraction, containing 18 acres, and an option on the Southwest Sulphur Group of 11 claims. It adjoins the Crater group of mines on the south and is north of the Gulch group of claims. The property is located in the Last Chance Mountains, 64 miles east of Zurich, a station on the Owens Valley Branch of the Southern Pacific Railroad; elevation 5300 ft.; owner, *Italio Sulphur Industries Co.;* Vincent Burchiere, president and manager.

Sulphur occurs in limestone, with a strike of NW. and SE.; dip 60° W.; width 6 ft. to 8 ft. The deposit is high grade, carrying from 70% to 85% sulphur.

Development on Fraction Claim consists of an incline shaft 50 ft. deep, with a drift southwest 50 ft. A number of shafts from 50 ft. to 75 ft. deep have been sunk on Southwest Sulphur claims, developing some high-grade ore. The thickness varies from 6 ft. to 12 ft.

PHOTO. 19. 3-Compartment Sulphur Ovens, Fraction Sulphur Mine, Italio Sulphur Industries Co., Last Chance Range of Mountains, Inyo County.

Sulphur ore mined on Fraction Claim is hauled by truck to 3 sulphur ovens, each oven having a capacity of 25 tons of crude ore. The ovens are 12 ft. in height and 11.6 ft. in diameter. The refined sulphur is drawn out of ovens into wooden molds. The individual cakes weigh 175 pounds each. The refined sulphur carries 99.5%.

At the time the property was visited there were 50 tons of refined sulphur on hand for shipment. Three men are employed.

Gulch Group of Sulphur Mines. It comprises 10 claims, situated in T. 8 S., R. 39 E., in the Last Chance Mountains, 64 miles east of Zurich, a station on Owens Valley Branch of the Southern Pacific Railroad; owners, Frank Rossi and Tom Wade, Big Pine, Calif.

The deposit was located by James Jacoby, Denver, Colo., in 1918 and relocated by Frank Rossi and Tom Wade, of Big Pine, in 1920.

The sulphur occurs in pure, crystalline form, intermixed with a koalinized material in limestone, gypsum, and cherty shales. Three parallel strata of sulphur occur in limestone. These strata strike north and south and dip 40° W. The thickness varies from 10 ft. to 20 ft.

Development consists of open cut 200 ft. in length by 50 ft. in width and 30 ft. high. Other development consists of tunnels and shallow shafts. In open cut there is exposed 20 ft. in width stated to carry 40% sulphur and 10 ft. of massive crystalline sulphur said to be 90% pure. Idle.

TALC

Talc has been commercially produced from deposits on the east slope of the Sierra Nevada, west of Big Pine, from both the east and west slopes of the Inyo Mountains, east of Keeler, from the east slope of the Panamint Range, on the west side of Death Valley and from Kingston Range, southeast of Shoshone.

Blue Star Mines, Ltd., has 9 claims on Big Pine Creek, on the east slope of the Sierra Nevada, 9 miles west of Big Pine; elevation, 8000 ft.; owner, Blue Star Mines, Ltd.; A. Getty, president, 840 San Julian St., Los Angeles.

The talc, which is white and free of lime, occurs in irregular masses in the serpentine or on the contact of serpentine and crystalline limestone. The largest of these masses as yet encountered is up to 15 ft. wide, 70 ft. long by 45 ft. high. Square-set system of mining is used.

Development consists of a tunnel driven SE. 200 ft. At 140 ft. from the portal a drift has been driven SW. 120 ft. Adjacent to the talc the limestone has been quarried. The quarry pit is now about 50 ft. long, 40 ft. wide and 30 ft. high. These materials are lowered down the hillside on a 1200-ft. gravity tram to a 3-compartment bin. Trucks take the talc and limestone 11 miles to the grinding plant at Zurich, a station on the railroad, 2 miles east of Big Pine. The grinding plant consists of the following: 11-in. by 18-in. jaw crusher, elevator to bin; to Raymond mill, 48-in. fan to cyclone dust collectors and Bates packer. Fines from cyclone to 96 cotton and silk tubes, to single-nose Bates packer. All machines have individual motor drives. The warehouse is 100 ft. by 160 ft.

Eight men are employed at the mine, 5 at the mill and 2 truck drivers.

Davis Talc Deposit (High Chief), comprising 5 claims, is situated on the west slope of the Inyo Mountains, 4 miles east of Zurich, a station on the Southern Pacific Railroad; elevation 4500 ft.; owner, Mrs. J. E. Davis, Big Pine, Calif.

The talc, having a maximum thickness of 20 ft. to 30 ft. is interbedded with strata of hard limestone. Strike NE.-SW., dip 30° NW. It is traceable on surface for a distance of 750 ft.

Development consists of tunnel driven N. 10° W. 50 ft., then 100 ft. northwest in talc. Another tunnel 30 ft. below has been driven N. 10° W., 100 ft. in limestone. In 1937 the property was under lease to the Blue Star Mines, Ltd. This company mined 200 tons. Idle.

Death Valley Talc Company's property, comprising 10 claims, is on the west side of Death Valley, in the Panamint Mountains, 30 miles south of Furnace Creek Ranch; owner, Death Valley Talc Co., S. D. Pepin, 421 South Westminster Ave., Los Angeles.

The talc up to 30 ft. thick occurs along the contact of dolomitic limestone and serpentine. It has a northeast strike and dips about 25° SE. The outcrop may be traced for about 6000 ft. The talc is white and contains little or no lime.

It has been opened on the south side of the canyon by a crosscut south 80 ft., drift E. 35 ft. and W. 125 ft. At 75 ft. west of the crosscut, a raise has been driven to the surface. At the end of the crosscut, a winze has been sunk 78 ft. on 20° inclination.

The following grinding plant has been erected on the south side of the canyon: 40-ton bin, steel chute about 100 ft. long, to hammer mill, elevator, to air separator where minus 200 product is taken out to two other air separators, products minus 400 and minus 700 mesh; oversize to 6 by 5 pebble mill, discharge back to air separation system. Products are sacked by hand. Sixty h.p. Venn-Severn oil engine supplies the power. Capacity 36 tons per day.

When operating 8 men are employed.

Florence Mine, comprising 6 claims, is in the Cerro Gordo Mining District, on the east slope of the Inyo Mountains, about 3 miles east of Cerro Gordo; owner, *Sierra Talc Co.;* P. H. Booth, president; Franklin Booth, secretary.; W. A. Reid, superintendent.

Vein is from 2 ft. to 6 ft. wide, strikes N. 85° E. and is horizontal. Ore occurs in lenses associated with dolomite. Talc is of a good quality but the lenses are thin and spotty.

About 800 tons was shipped by truck to the Sierra Talc Company's mill at Keeler. All ore came from development tunnels, shafts and surface trenches. Idle.

Pacific Coast Talc Company (formerly Mount Whitney Talc Co.) Deposit. This deposit is in Sec. 25 and 36, T. 18 S., R. 40 E., M. D. M., on the west slope of the Inyo Mountains, 8 miles northwest of Darwin. They have 9 claims in Sec. 25 and have leased 80 acres in Sec. 36 from the State of California; elevation 5400 ft.; owner and lessee, Pacific Coast Talc Co., 2149 Bay St., Los Angeles, W. S. Lockhart, president.

Talc occurs in lenses in a dolomitic limestone near its contact with an igneous intrusive. The general strike is N. 35° W., dip about 55° E. The lenses vary up to 9 ft. in width. As mined, the width averaged about 6 ft. One lens has been mined along a length of 80 ft.

Development consists of tunnel driven northwest 250 ft., where it connects with a shaft 50 ft. below the surface. A winze has been sunk below tunnel 110 ft., with levels at 60 and 110 ft.

There is another talc vein some 1200 ft. north of these workings. Strike N. 30° W. It is about 15 ft. wide. A tunnel has been driven southeast 110 ft. on this vein. Several thousand tons of talc have been shipped from these workings to a grinding plant in Los Angeles.

Sierra Talc Co. (Inyo Talc Co., Simonds Talc Mine) is situated in the Darwin District, 17 miles southeast of Keeler; elevation 5850 ft.; P. H. Booth, president; Franklin Booth, secretary; W. A. Reid, superintendent.

The deposit occurs in a crushed zone in impure limestone, close to or in contact with an igneous intrusion. The strike of the orebody is N. 30° E. and dip is 60° W. to vertical. The outcrop can be traced for 3000 ft. The color is gray, green, and white.

The deposit is developed by a tunnel 900 ft. long driven southeast through limestone and a 200-ft. crosscut east. At 260 ft. from the portal, it cut the glory hole orebody which was 70 ft. wide and has been stoped to the surface. The bed was 70 ft. thick at this point. Along the crushed zone east of the tunnel, a number of lenses of talc of good quality, 20 ft. to 60 ft. wide, have been developed. A winze sunk on a 45° incline 185 ft. deep, with a 280-ft. crosscut southeast developed a second orebody. At about 750 ft. southeast from the portal, a winze has been sunk 50 ft. on a 56° incline and a crosscut driven east for 40 ft. and west 25 ft.

In October, 1937, three men were employed sorting and loading ore from a caved stope at the end of the tunnel and tramming ore to the bin from which it is hauled by trucks to the mill at Keeler.

Sierra Talc Mill is located at Keeler, Calif.; C. O. Best, superintendent; owner, *Sierra Talc Co.*

The ore is hauled in five $5\frac{1}{2}$-ton trucks from the mine and dumped into ore bins; capacity 800 tons. It is loaded into rubber-tired, concrete buggies and wheeled to a Wheeling jaw crusher; crushed to $\frac{1}{2}$-in. and elevated 40 ft. by a bucket elevator to the crushed-ore bin; capacity 18 tons. From this bin the ore flows to a Raymond whizzer separator with a Reeves variable speed drive. Six products, from 200 mesh to 350 mesh can be obtained by changing the speed of the whizzer separator. The ground talc is delivered into powder bins of 3, 6, and 12-ton capacities by an exhaust fan. It is loaded into sacks for market by 2 Iron Clad and one Bates packer-machines. Plant capacity is 30 tons per shift to 200 mesh or 25 tons to 325 mesh. All machinery is electrically driven.

Three men were employed in October, 1937.

Bibl.: State Mineralogist's Reports XV, pp. 126-127; XVII, pp. 300-301; U. S. B. of M. Rept. of Investigations No. 2253, May, 1921.

Warm Springs Canyon Talc Deposit comprising 5 claims, is on the east slope of the Panamint Mountains, 2 miles south of Warm Springs. It is in T. 22 S., R. 47 E.; owner, Miss Louise Grantham, 932 South Irolo St., Los Angeles.

Development consists of 2 tunnels and several open cuts. Showings reported in these openings would indicate a large deposit of talc of good quality. Idle.

Western Talc Company has 2 claims in Anvil Springs Canyon, 9 miles west of the road which traverses the west side of Death Valley; elevation about 2100 ft.; owner, Western Talc Co.; F. H. Savell, president, 1901 East Slauson Ave., Los Angeles.

On these claims occurs a talc deposit at the contact of dolomitic limestone and serpentine. The strike is N.-S. and the dip, while not as yet definitely determined, appears to be about 40° E.

A tunnel is being driven into the hill some 60 ft. below the outcrop. This tunnel is driven nearly north for 320 ft. through a granitic rock, then turns easterly for 105 feet. The last 85 ft. is in serpentine. The talc vein has not yet been reached.

Equipment consists of a portable compressor and tent.

Three men are employed driving tunnel.

White Mountain Talc Mine (Troeger), comprising 2 patented claims owned by Roy Troeger, of Los Angeles, is situated on the east slope of the Inyo Mountains, about 6 miles northeast of Cerro Gordo at an elevation of 8000 ft. It was operated under lease and bond by the *Sierra Talc Co.,* from September, 1935, to October, 1937.

The vein strikes east and west and lies about horizontal in beds associated with dolomite and calcite. Talc is white to gray and of good quality.

Developed by a tunnel 300 ft. east on the vein and a 50-ft. winze, 150 ft. east of the portal. Crosscuts east and west 50 ft. from the bottom of the winze. Numerous surface trenches and short tunnels. About 900 tons was shipped to the Sierra Talc Company's mill at Keeler.

The Sierra Talc Co. constructed 4½ miles of road to the property; also installed a one-inch pipe line from Cerro Gordo Spring to the mine, a distance of one mile. Idle.

Bibl.: State Mineralogist's Report XXII, p. 524.

SALINES

BORAX

The colemanite (calcium borate) deposits occur in the foothills of the Black Mountains east of Furnace Creek. They extend in a narrow belt for many miles and are owned by the Pacific Coast Borax Co. The borate-bearing beds in the vicinity of Ryan are a part of a series of Tertiary lake beds which consist of thin-bedded, light-colored shales. Underlying these shales are thick beds of sandstone and tuff. The borate-bearing beds are capped with basalt which forms the crest of the ridge back of the mines. The colemanite deposits are distinctly bedded and vary in thickness up to 100 ft. The strata have been considerably faulted so there is no great regularity to the deposits. The borax deposits of Inyo County are the largest deposits of colemanite and have been the most productive of any county in California. The county has been a steady producer of borax since its discovery in 1874, until discovery and development of extensive deposits of the new mineral known as 'kernite', (or rasorite), a sodium borate, in southeastern Kern County, near Kramer. In 1926 the Pacific Coast Borax Co. acquired the kernite deposits in Kern County and suspended operations at the mines near Ryan, Inyo County; also moved the calcining and concentration equipment at Death Valley Junction to their new plant at Borate, Kern County.

Bibl.: State Mineralogist's Reports XV, pp. 62-69; XVII, pp. 274-277; XXII, pp. 524-526.

GYPSUM

Deposits of gypsum occur in the Resting Springs District, on the Morrison Ranch, one mile northeast of Acme Station, on the Tonopah & Tidewater Railroad. The Pacific Coast Borax Co. owns a large deposit of gypsum located in the foothills of the Black Mountains.

Bibl.: State Mineralogist's Reports XV, pp. 85-87; XVII, p. 282; XXII, p. 526.

NITRATES

The nitrate deposits are situated in the southeastern part of Inyo County along the Amargosa River, near the boundary between Inyo and San Bernardino counties, and are associated with beds of clay of the Tertiary age. The principal deposits are known as the Confidence beds, located in the Confidence Hills which extend from a point nearly opposite the old Confidence mill, 10 miles northward along the west side of south Death Valley. The Confidence nitrate field is about 27 miles by road south of Shoshone.

The Zabriskie, Resting Springs, Tule Springs, Upper Canyon and Lower Canyon nitrate deposits are located in the valley of the Amargosa River, between Shoshone and Sperry stations on the Tonopah & Tidewater Railroad. There has been no commercial production.

The reader is referred to U. S. G. S. Bull. 724, Nitrate Deposits in the Amargosa Region Southeastern California; also U. S. G. S. Bull.

820, pp. 62-71 and pp. 88-91; State Mineralogist's Reports XV, pp. 117-119; XXII, p. 526; Bull. 24, pp. 165-174.

POTASH

Potash occurs in Inyo County in small amounts in the saline deposits of Death Valley, Deep Springs Valley, Owens Lake and Saline Valley. There has been no commercial production to date from the above-mentioned deposits, although considerable test work has been made on the Deep Springs Valley lake deposits.

Bibl.: State Mineralogist's Reports XVII, p. 296; XXII, p. 526; U. S. G. S., Bulletins No. 540 and No. 580.

Deep Springs Valley Deposit. It comprises 2560 acres on the east side of Deep Springs Lake. The land in the lake and on the clay flat immediately adjoining the lake, comprises 640 acres, in the NW. ¼ of the SW. ¼ of Sec. 9; and NE. ¼ of SW. ¼ of Sec. 4; and one-half of NW. ¼ of Sec. 4, in T. 8 S., R. 36 E., 24 miles east of Big Pine; elevation 5000 ft.; owner, A. G. Barmore and associates, of Big Pine.

The property was formerly owned by *Inyo Chemical Co.*, Henry M. Leland, president, Detroit, Mich. This company put down test holes and did some experimental work on the brines for the extraction of soda and potash.

From a hole 10 ft. deep sunk on the northeast edge of the lake, about 200 yards northwest of the center of Sec. 4, T. 8 S., R. 36 E., a sample of the brine, analysis by Smith-Emery Co., showed 14.19% total salts, which contained 7.05 K_2O. Sample of lake water showed 8.42% salts, and the salts contained 4.81% K_2O. No. 2 hole, 36 ft. deep is in the SE. ¼ of the NW. ¼ of Sec. 4, T. 8 S., R. 36 E. No. 3 hole is 39 ft. deep and located in the NE. ¼ of the SW. ¼ of Sec. 4.

Determinations of sample of brine from Hole No. 3.

Sample in ft.	*Potash in Brine*	*Water Sol. Salts*	*Potash in Salts*
0 ft.–4 ft. 6 in.	1.25%	9.63%	12.99%
4 ft. 6 in.–8 ft.	2.03%	9.80%	20.64%
8 ft.–12 ft.	1.74%	14.60%	11.90%
14 ft.–21 ft.	1.14%	9.50%	12.00%
21 ft.–39 ft.	1.16%	10.60%	10.99%

Analysis of brine by Smith-Emery Company.

Water Sol. Potash (K_2O)	1.38%
Chlorine (Cl)	6.72%
Sulphur trioxide (SO_3)	3.80%
Boron trioxide (B_2O_3)	0.08%
Carbon dioxide (CO_2)	0.82%
Total solids	20.32%

Hypothetical form of combination:

	On Brine Basis	*On Dry Solid Basis*
Potassium chloride (KCl)	2.19%	10.75%
Sodium chloride (NaCl)	9.37%	45.98%
Sodium sulphate ($NaSO_4$)	6.74%	33.07%
Sodium borate ($Na_2B_4O_7$)	0.11%	0.54%
Sodium carbonate (Na_2CO_3)	1.97%	9.66%
		99.00%

Idle.

SALT

Sodium chloride is deposited as a major ingredient in the saline crusts of Death Valley, Saline Valley and Salt Wells Valley and in the brines of Owens Lake. The only commercial production in the county has been from the Saline Valley deposits.

Saline Valley Salt Deposit. It is situated in Saline Valley, east of the Inyo Mountains, 13 miles northeast of Swansea and 50 miles by road from Keeler, a station on the California and Nevada Railroad; elevation, 1100 ft. Holdings comprise 3 patented placer claims of 160 acres each; total 480 acres. Also 4 patented placer claims of 160 acres each; total 640 acres. The total salt land owned and controlled is 1120 acres. The company also owns 160 acres of land at the southwest end of the aerial tramway, at Tramway Station on the Southern Pacific Railway, upon which is located a mill and dwellings for employees; owner, *Taylor Milling Co.*, 1520 San Fernando Rd., Los Angeles.

History: The property was operated by *Saline Salt Co.*, White Smith, president, Bishop, Calif., from 1911 to 1913; from 1915 to 1919 by *Owens Valley Salt Co.*, of Los Angeles; from 1926 to 1930 by the *Sierra Salt Corporation*, of Los Angeles, G. W. Russel, president; A. S. Henderson, secretary. This company shipped a considerable tonnage of salt.

The total area of the salt field as shown by a dotted blue line on the Ballarat Quadrangle map of the U. S. Geological Survey, is about 16 square miles. The depth of the salt deposit is known to be at least 30 ft., as determined by bore holes sunk a number of years ago. The analysis shows the salt to be of rather exceptional purity. One of the principal factors in its favor is the absence of soluble salts of magnesium or calcium. Due to the large area and the depth of the field there is an inexhaustible supply of sodium chloride. Water for operation of the salt field is secured from Hunter Creek and from 40-acre tract of water-bearing land. Harvesting season is from May 1 to October 1 when the solar heat reaches 115° to 120° F.

Analysis of a sample of unwashed and washed salt, by Smith-Emery Co., of Los Angeles, gave the following results:

	Unwashed	*Washed*
Sodium chloride	98.71%	99.60%
Calcium sulphate	none	none
Sodium sulphate	1.26%	0.37%
Magnesium sulphate	none	none
Magnesium carbonate	none	none
Sodium borate	none	none
Water, insoluable	0.03%	0.03%
	100.00%	100.00%

When the property was in operation by the Sierra Salt Corporation, the aerial wire-rope tramway which extends from Saline Valley salt field to Tramway Station, a distance of 13 miles, was overhauled and put in first-class condition in 1929. About 30,000 tons of salt has been transported over the tramway since it was built in 1913. The tramway is equipped with 268 buckets and carriers, the capacity of each being 12 cu. ft., which at 60 lb. per cubic foot, would carry 720 pounds each, of dry salt. The mill at Tramway has a capacity of 70 tons of salt per day of 24 hours.

Mill equipment: One hot-air dry furnace; one revolving dryer, 4 ft. diameter by 36 ft. in length; 2 sets of grinding rolls; one single-deck

scalping screen; one double-deck scalping screen; 2 double-deck Hummer electric vibrating screens. All equipment is electrically operated, gravity flow of product from all screens to finish bins, 5 in number; packing devices and automatic scales.

Electric power for operation of tramway and mill is secured from Los Angeles Bureau of Light & Power. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 122-123; XVII, p. 297; XXII, p. 527; U. S. G. S. Bull. 540, pp. 416-422; Transactions of American Society of Civil Engineers, Vol. LXXXI, p. 709 (1917).

SODA

Pacific Alkali Co. has a plant on the west shore of Owens Lake about 10 miles south of Lone Pine. Harvey S. Mudd, 1206 Pacific Mutual Bldg., Los Angeles, is president of the company; Geo. E. White, general manager; Geo. D. Dub, superintendent.

This plant began real operations in about 1930. The brine of Owens Lake is pumped through 2½ miles of 14-in. pipe into 3 vats

PHOTO. 20. Pacific Alkali Company's Soda Plant, Owens Lake, Inyo County.

which range from 15 to 50 acres in size. It is left here until evaporation has raised the soda content to 12% to 14%. From the vats it goes to a storage reservoir where it is pumped into 16 six-ft. in diameter by 80 ft. high carbonating tanks. The carbonating is done by CO_2, solids going to centrifugal dryers. The soda is further dried and screened for laundry use or is calcined in Herreshoff furnace, making soda ash which is screened and sacked.

After soda is removed, the liquor is chilled either by spraying or the atmosphere, removing the crude borax. This sludge goes to a 6-ft. Oliver filter. Liquor is returned to the lake. The cake is diluted and pumped to tanks where it is redissolved, treated chemically and filtered in Sweetland filters, chilled and borax crystals go to centrifugal dryer, screened and packed, liquor to lake.

Capacity of plant is about 1000 tons of soda and 2000 tons of borax per season. Power is supplied by Los Angeles Bureau of Power and Light.

Fifty men are employed.

Natural Soda Products Co. has a plant just south of Keeler on the east side of Owens Lake. Stanley Pedder is president; Charles Eckland, secretary, 405 Montgomery St., San Francisco; G. A. Keep, general superintendent.

In the past two years this company has spent $500,000 erecting a 100-ton plant employing a new process for the manufacture of soda ash. At this time they do not care to divulge the details of this process.

This plant has been shut down for the last three months (August, 1938) on account of the fact that too much water has been allowed to flow into Owens Lake, instead of being diverted into the Los Angeles Aqueduct.

Forty-four men are normally employed.

Bibl.: State Mineralogist's Reports XV, pp. 125-126; XVII, p. 299; XX, pp. 190-191; XXII, p. 530.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In This Issue

In addition to the Division's general mining report on Inyo County, two special geologic reports have been contributed to this issue: one is on the geology of the silver-lead mining district of Darwin, by Vincent C. Kelley; the other is on the geology of the sulphur deposits which occur on the west slope of the Last Chance range, Inyo County, by Edward D. Lynton. The first represents the results of field and laboratory study done in connection with an advanced degree granted by the California Institute of Technology; the second represents the results of special geological investigation, generously released for publication by the commercial concern for which it was done.

In Preparation

A map of the State showing not only the boundaries of the geologic formations, but also all of the quicksilver deposits known to be of any consequence in California, is now being prepared by the Geologic Branch. In the margins of the map will appear much significant information as regards the geology, economics, and production of quicksilver. The scale of the map will be one-half that of the Geologic Map of California, or 1 inch=16 miles. It will represent one of a series of such State mineral deposit maps, the data for which are now being compiled.

GEOLOGY AND ORE DEPOSITS OF THE DARWIN SILVER-LEAD MINING DISTRICT, INYO COUNTY, CALIFORNIA *

By Vincent C. Kelley **

OUTLINE OF REPORT

* This report represents the results of a doctorate thesis prepared at the California Institute of Technology.

** Instructor at the University of New Mexico, Albuquerque.

OUTLINE OF REPORT—Continued

ABSTRACT

The Darwin Silver-Lead mining district is located in the Darwin Hills, Inyo County, California. These hills rise 1000 to 1500 feet above the more or less flat top of a large mountain mass which lies between Owens Valley on the west and Panamint Valley on the east.

The flat portion of this large mountain block or horst covers some 250 square miles and is called the Darwin plateau. It is delineated on the north and the northeast by abrupt descents into Saline and Pana-

mint Valleys. On the southeast the plateau is bounded by the Argus Range which rises abruptly by a series of faults above a somewhat dissected portion of the plateau. On the southwest the plateau is bounded by the Coso Range which has been elevated also by a recent fault. On the west the plateau is bounded in part by the southern end of the Inyo Range, and in part merges into broad washes dissected in lake beds and descending gradually into Owens Lake.

The Darwin Hills owe their origin to faulting, particularly on the west side, and to recent dissection of the southern part of the plateau by the Darwin Wash.

The oldest rocks within the hills are a series of Pennsylvanian limestones, shales, and quartzites. The strata of this series are considerably folded, especially along the eastern slopes of the hills. Impure limestones comprise the bulk of the Pennsylvanian rocks which aggregate some 5000 feet as exposed in the Darwin Hills.

Intruded into the folded series is an elongated stock. This stock, five miles in length and two-thirds of a mile in maximum width, parallels the north-northwesterly trend of the stratified rocks. The stock widens in depth and cuts across the west limb of a large fold. The intrusive rock is medium-grained quartz diorite on the average, bu more acidic and basic phases are common.

The igneous intrusion has effected marked transformations in the country rock, particularly in the limestones. The metamorphic aureole is as much as 2500 feet in width. Within this zone the limestones have been converted into silicate-carbonate rock termed tactite. The silication of the limestone was caused by the action of igneous emanations which accompanied the intrusion. The original stratification of the limestones is retained despite the transformations. The zone as a whole has been bleached to a grayish or greenish white, which stands in contrast to the gray or brown of the unaltered sedimentaries.

Following the metamorphism and the consolidation of the stock, the rocks were fractured and faulted. These fractures fall into two prominent sets. One set trends northwesterly and the other east-northeasterly nearly at right angles to the stock. The major or master fracture of the district is a large fault on which the greatest component of displacement appears to be horizontal. This fault crosses the northern end of the hills where it is made plain by both structural and physiographic effects. The principal movement on most of the faults has been such as to displace the north walls westward.

The ore mineralization took place after the fracturing, and the localization of the ore mineralization shows three structural controls: igneous contacts, bedding planes, and cross fractures. Of the fractures only those trending east-northeasterly have proved productive. The northeasterly-southwesterly stresses which caused the faulting and which were active during part of the mineralization at least were such as to more effectively open the east-northeasterly fractures to the ore-bearing solutions. On the west side of the stock the beds roughly parallel the igneous contact and only on this side are important deposits of ore found at the contact between the stock and the country rock. Deposits along favorable bedding planes are found on both sides of the

stock. Deposits along faults or fissures are more numerous and more productive on the east side of the stock.

The original ore mineralization of the deposits consists principally of galena with lesser quantities of sphalerite and chalcopyrite and minor quantities of the gray-coppers, luzonite and tennantite. Near the surface the sulphides have been extensively oxidized and much of the ore consists of gossan in which is found principally the lead-carbonate, cerusite. Lesser quantities of anglesite, smithsonite, malachite, and chrysocolla with small quantities of horn silver are also present. The associated gangue consists of pyrite, jasper, calcite, fluorite, kaolin, and occasionally barite.

The mineralization belongs to the intermediate or upper mesothermal group of ore deposits having thus originated in the presence of temperatures and pressures neither extremely high nor extremely low. The geologic epoch or period of mineralization probably occurred during late Mesozoic comparable in time with the formation of the gold deposits of the Mother Lode of California.

INTRODUCTION

LOCATION

The Darwin district is located within the desert basin and range province of eastern California about 20 miles east of Owens Lake (Fig. 1). Darwin is 230 miles from Los Angeles and 24 miles from Keeler, the branch terminus of the Southern Pacific railroad. The Death Valley highway which passes through Darwin has been steadily improved since the establishment of the Death Valley National Monument in 1933. Eastward from Darwin for many miles the road follows the wash which drains a large upland area subject to summer cloudbursts. Because of the repeated destruction of the section of the highway in the wash a new road has been proposed and surveyed which will pass six or eight miles to the north of Darwin.

The area described herein as the Darwin silver-lead district is coextensive with the Darwin Hills which in turn fall within the legal confines of the New Coso mining district. The town of Darwin lies at an altitude of 4750 feet along the western edge of the Darwin Hills. The population of Darwin and the adjacent camps in 1937 was about three or four hundred.

HISTORY

The Darwin deposits were discovered in the early seventies and the district flourished during the first two decades largely from the rich surface ores. Before 1880 several smelters had been built near Darwin with capacities from 20 to 100 tons. In 1875 water was piped down from the Coso Mountains, a distance of eight miles. During those early days Darwin is said to have spread eight blocks in either direction and to have had a population of 5000.

Only the slag dumps mark the former presence of the smelters. Poor transportation facilities and exhaustion of the rich near-surface ores caused the district to lie dormant or only sporadically active until the World War gave new impetus to mining. About that time many of the larger properties were consolidated and development began anew with modern methods and equipment. In the early twenties a new camp and mill were erected and additional water was obtained from the Darwin basin. Although these were shut down during the depression, plans for their reopening were formulated in 1936, and mining began again early in 1937. The district is estimated to have produced nearly $6,000,000 in lead, silver, and zinc. About half of this amount was gained before 1900.

PHYSIOGRAPHY (See Figs. 2 and 3)

The Darwin Hills, in which the deposits occur, lie near the center of a large arched mountain block some 30 miles in width, which trends in a north-northwesterly direction in common with other ranges in this region. This large block is usually considered in three smaller and

separate physiographic units, namely, the Inyo, Coso, and Argus Ranges. The Darwin region is a separate unit or central plateau above which these adjacent ranges have been elevated by faults. The general character of the oldland surface which existed prior to the basin and range faulting of Quaternary time is still well preserved on the Darwin plateau.

The Darwin Hills rise only slightly above the general level of the plateau and trend in a northwesterly direction. The Darwin Hills proper are six miles in length and rise from 500 to 1000 feet above the broad Darwin Wash which borders the hills on the west, south, and east. One's first impression is that the smaller physiographic features on the plateau, such as the Darwin Hills, are erosional remnants on the oldland surface. Obscure structural evidence, however, in the form of remnants of displaced lava sheets indicates that even the Darwin Hills are a small fault block on the plateau surface.

Erosion of the Darwin Hills has reached the stage of early maturity since the Quaternary elevation. Throughout most of this period the erosional base of the hills has been the surface of the plateau itself. Very recently, headward erosion in the Darwin Canyon and Wash has cut into this old base east of the hills and is at present effecting their rejuvenation in preparation for a second dissection.

CLIMATE

The climate at Darwin is similar to that of the basin and range province in general. Scant rainfall, low humidity, and continued moderate shifting winds are the characteristic climatic elements. On the whole the climate at Darwin is perhaps somewhat more equable than in the adjacent areas. In the winter the temperature is apt to be very little lower than that of the Owens Valley to the west where cold air masses settle from the snow-covered Sierra Nevada and Inyo Range. During the summers the temperatures are correspondingly cooler than in the adjacent desert basins. The summer temperature rarely exceeds 105° F. The average rainfall at Keeler, the nearest station for which records have been kept, is only slightly over three inches. Although the rainfall is undoubtedly greater at Darwin, it probably does not exceed an average of four or five inches. Most of this comes during the winter months. Scattered rainfall in the form of thunder showers is common during the months of July and August, but much of this runs torrentially into the adjacent basins.

WATER-SUPPLY

No water for domestic or mining purposes is available in the Darwin Hills. The deepest mines in the district, the Lucky Jim and the Lane, are dry on their lowest levels which are 1000 and 800 feet, respectively. The lowest level in the Lane mine is lower than the bottom of the Darwin Wash two miles down the alluvial slope to the east, where abundant water is available. The dryness of the Lane mine thus indicates the influent nature of the Darwin Wash.

A gravity water supply for mining and domestic purposes was developed as early as 1875 by an eight-mile pipe line from a spring in the Coso Mountains. This sold at the rate of a half cent a gallon for mining purposes and one cent a gallon for domestic purposes. Water

for subsequent mining and milling operations was obtained from a shallow well near the head of Darwin Canyon where the large underground water supply from the 160 square miles of watershed on the Darwin plateau is forced near the surface. The water is pumped through a four-inch pipe line with a lift of 800 feet in three miles to the mill and 1800 feet in four miles to the mine and camp. The Keystone Darwin Limited plans to pump water to their camp from a new well in the wash near that of the Darwin Lead Company. Abundant water should be available in the wash upstream from these wells but at greater depths. In 1937, the domestic supply for the town still came from the spring in the Coso Mountains at a cost of one cent a gallon.

PAST WORK

From time to time since the discovery of the district in 1874 the reports of the State Mineralogist have contained brief descriptions of the mines and geology. These have been reports on the existent mining operations, equipment, and production, with notes on the local geology. The only strictly geological report was written by Adolph Knopf as the result of a five-day examination of the district following his work in the Inyo Range in 1913.

As in the present report, Knopf's observations were confined almost exclusively to the Darwin Hills. Knopf determined the age of the limestones as Pennsylvanian, summarized the general geology, and from study and description of the individual mines and prospects, deduced a genetic relationship between the pyrometasomatic deposits and fissure veins of the district. In addition, he briefly described the general character and composition of the intrusive rocks and the associated tactites.

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SCOPE OF PRESENT WORK

The present report is the outgrowth of nearly two months of field work during the summers of 1935 and 1936 in which time a topographic and geologic map of the Darwin Hills was made on the scale of 1000 feet to the inch. In addition, geologic reconnaissance mapping was extended over much of the Darwin plateau and small portions of the Argus and Coso Ranges with the view of obtaining a broader geologic background for the detailed work in the Darwin Hills. Detailed geologic maps were made of the Defiance-Independence mine group on the scale of 200 feet to the inch.

During the investigation the following features were given special consideration: (1) the character of the silicate zone about the intrusive, (2) the origin of the zone, (3) the form of the intrusive, (4) the structural pattern of the fissure system, and (5) the geologic occurrence of the orebodies. The wide silicate zone about the intrusive originated under the influence of magmatic emanations which thoroughly penetrated the surrounding impure limestones. Although the composition of the original beds was in many places the controlling factor in the resulting mineralogic make-up of the zone, concrete evidence is present for the introduction of large quantities of new materials, principally silica. The deposits are classed as mesothermal in contrast to the pyrometasomatic grouping given by Knopf. The period of metallization is sharply set off in time from the silication * process by consolidation of the magma and by post-intrusive fracturing.

ACKNOWLEDGMENTS

The field work and the compilation of this report were completed while attending the California Institute of Technology in the Balch Graduate School of the Geological Sciences. The writer wishes to thank the members of the faculty for criticism of the manuscript and for suggestions in the field. At Darwin many of the residents helped with information about the history of the camp, locations and names of mines, etc. Special thanks are due to H. E. Olund, manager, and Sam Davis, assistant manager of the Darwin Lead Company; L. D. Skinner, owner of the Christmas Gift mine; A. Yoder, manager and superintendent of the Keystone Limited; Theo Peterson, owner of the Darwin Garage; and Alex Rouna, owner of the Standard and Fairbanks mines.

* The process of changing to silicates; whereas *silification* is the process of changing to silica, either as quartz, chalcedony, or opal.

GENERAL GEOLOGY

GENERAL GEOLOGIC SETTING

Two contrasting rock types underly the Darwin plateau. The southwestern portion, generally south and west of the road from Darwin to Keeler, is underlain by granodioritic rock closely comparable in texture, composition, and structure to the intermediate rock of the Sierra Nevada batholith. Occasional patches of older rocks are present as for example on Centennial Flats where large deposits of iron ore occur in a remnant of schist and marble. Commonly the granodiorite of this region is cut by basic dikes which often display marked persistency for considerable distances. The widespread granodioritic body of the area is referred to in this report as the Coso batholith.

The northeasterly part of the plateau is underlain chiefly by folded upper Paleozoic rocks similar to those in the Darwin Hills and in the north end of the Argus Range. Knopf (pp. 36-48, 1918) has described these rocks in the south end of Inyo Range southeast of Keeler where they form folds of Mesozoic age. In the Inyo Range southeast of Keeler these folds are covered by extensive lava sheets, but they emerge again along the strike to the southeast of the Darwin plateau. There they are partially cut off and offset in their distribution around the Coso batholith. The same system of folds passes through the Darwin Hills and thence southeastward, by step-faulting into the Argus Range.

Here and there the Paleozoic rocks are pierced by small intrusives which may well be off-shoots from the Coso batholith. Knopf (p. 5, 1918) described such intrusives as common in the Inyo Range. In the general Darwin region they are exemplified by the quartz diorite stock of the Darwin Hills, the small granitic intrusion near the Lee mine, the gabbroic stock at Darwin Falls, the monzonite plug at the north end of the Argus Range, and several smaller intrusives southward in the same range. Northeast of Darwin the truncated Paleozoic beds are extensively capped by basaltic flows which form a large part of the plateau surface and may conceal the presence of other intrusive stocks.

SEDIMENTARY ROCKS

Pennsylvanian Series

A series of Pennsylvanian strata consisting largely of pure and impure limestones intercalated with some quartzite and shale constitute the oldest rocks of the Darwin Hills. Fossil corals, crinoids, fusulinae, bryozoa, and occasional ammonoids occur in these beds. The state of preservation of the fossils is usually rather poor and exact determinations are therefore difficult. On the basis of determinations made by George H. Girty, Knopf (1914) called the formation Pennsylvanian. The strata dip westerly across most of the width of the hills and therefore, excluding complete overturning for which there is no evidence, the younger beds crop out on the west flanks of the hills. The oldest beds, or the lowest in the exposed series, crop out on the

east side of the hills and locally they are considerably folded. The lower strata east of the stock and on the east side of the hills are generally drab and uniform gray or brown with few distinct horizons or marker beds. The younger strata, on the other hand, which crop out on the western slopes of the Darwin Hills, consist of and are marked by prominent, contrasting light and dark colored members. The beds along the western half of the hills generally dip steeply west and aggregate about 2500 feet in thickness. The contrasting nature of the members of a portion of this series is shown by the following section between the sill beneath the east escarpment of Ophir Peak to the western edge of the hills:

(1) 2-300 feet of thin-bedded, dark-gray, impure limestone
(2) 4-500 feet of white and grayish white limestones
(3) 3-400 feet of dark-gray to black limestones
(4) 4-500 feet of pure, massive, white limestones

Alluvium overlaps the youngest strata at the base of the hills and the Coso granodiorite probably intrudes the limestones a short distance beneath the alluvial cover. The members of the above series appear to finger and wedge out southward toward the Darwin Lead Company's camp, where they are further confused and their identity obliterated by local folding and silication. An isolated patch of folded, pure white limestone probably equivalent to the third member listed above occurs at the entrance of the Radiore tunnel.

A section across the southern end of the hills shows an inclined series dipping 40-60° west. The thickness of this section, although neither the top nor the bottom of the series is exposed, approximates 5000 feet. At the top of this section is a prominent member of dark-gray impure limestone which marks the bold front of the hills southward from the town of Darwin. To the north near Darwin the character of this member is obliterated by bleaching and silication; to the south it is partially cut out by a lobe of the Coso batholith. In the center of the hills along this east-west section silication has again obliterated the original nature of the sedimentary material, but along the southeastern tip of the hills at the statigraphic bottom of the section a dark-gray to black limestone member 6-700 fee in thickness makes up the oldest Pennsylvanian rocks in the Darwin Hills. This member occurs just east of the Columbia mine where it forms bold cliffs 2-300 feet high facing the Darwin Wash.

The east slope of the Darwin Hills consists of closely folded, thin-bedded limestone strata in which conspicuous lithologic members are absent except as noted above. The beds in general are drab brown and gray color. No white limestone strata occur and only occasional relatively thin, blue-gray limestone beds are present.

The blue-gray limestone which makes up so much of the Pennsylvanian rocks throughout the hills is commonly spotted in texture. In many instances this is due to fusulinal and crinoidal remains which, because of their differential coloring and solubility, cause a spotted texture in the outcrop. A similar spotty texture is also due to small lenses and nodules of chert in the limestone.

The lithology in the north end of the Darwin Hills north of the large east-west fracture here referred to as the Darwin tear fault

is noticeably different. Magenta, lavender, and brown, thin-bedded shales are common. A massive quartzite bed 30-40 feet in thickness crops out as a prominent ridge about 1300 feet north of the Lucky Jim mine. An even more striking feature of these beds is the increased spottiness of the limestones. Although some of this texture indicates organic origin, much of it is fragmental and undoubtedly many of the beds are depositional limestone breccias. No age determination was made of those beds north of the fault, but because of the structure and direction of displacement along the fault they are thought to be older than the beds south of the fault.

In connection with studies of the silication process a chemical analysis of a sample of typical blue-gray limestone from the ridge above the Thompson mine was made. This showed a content in $CaCO_3$ considerably higher than the average for limestones of Carboniferous age.[1]

The table below shows the comparison of the Darwin limestone with Daly's[2] analyses of Carboniferous and Cretaceous limestones.

Limestones	Ratio $CaCO_3 : MgCO_3$	Ratio $Ca : Mg$
Carboniferous	8.8 : 1	12.4 : 1
Darwin	22.8 : 1	31.5 : 1
Cretaceous	40.2 : 1	56.3 : 1

Richard Wallace of Darwin reports analyses of the white limestone on the west slope of the hills which show 98 per cent $CaCO_3$. The high ratio of calcium to magnesium in the Darwin limestone suggests that dolomitization has been relatively unimportant in the Pennsylvanian rocks.

Pleistocene Lake Beds

About 50 feet of nearly horizontal white lake beds have been exposed by recent dissection in the wash east of the Darwin Hills. The material of the beds is fine-textured and thick-bedded and probably originated, in part at least, from volcanic ash. The beds are capped by recent alluvium; their base is unexposed. In the Coso Mountains J. R. Schultz[3] has found similar beds of early Pleistocene or late Pliocene age overlying older gravels and in turn capped by basaltic lavas which are probably age equivalents of the lava sheets at Darwin. At Darwin, however, the age relationship between the lake beds and the lava sheets is reversed. The lake beds in the Darwin Wash are not capped by lava. Furthermore, about 700 feet east of the lake beds in the wash, on a small tilted fault block at the base of the Argus Range, basalt directly overlies Paleozoic beds and lake beds are absent. From this relationship it appears that the lake beds are not only younger than the basaltic lavas, but also that they are younger than the faulting which dislocated the basalt. Although beyond the scope of this report, the evidence suggests that the lowermost step fault in the Argus Range was at one time the obstruction to the drainage of the wash which created the lake in which the white beds accumulated. These lake beds, then, are distinctly younger than those

[1] Grout, F. F., Petrography and petrology: p. 302, 1932.

[2] Daly, R. A., Evolution of the limestones: G. S. A. Bull. vol. 20, p. 165, 1909.

[3] Schultz, J. R., Late Cenozoic vertebrate fauna from the Coso mountains: Carnegie Inst. Wash., Pub. No. 487.

described by Schultz in the north end of the Coso Mountains. If those in the Coso Mountains are early Pleistocene, then the Darwin lake beds may be middle or even late Pleistocene in age. No fossils have been found. Headward erosion in the Darwin canyon has subsequently dissected the lake beds by cutting through the outlet of the lake.

Recent Alluvium

The alluvial deposits of the broad washes and fans surrounding the Darwin Hills are of two types, older dissected gravels and recent gravels. The younger gravels are in part derived from the older and in places they grade into each other. These two types do not result from diastrophic rejuvenation, but rather from the down-cutting of the outlet to the Darwin lake which was the former temporary base level for the erosion around the Darwin Hills. The dissected gravel, where it overlies the exposed lake beds, is usually not more than 10 to 20 feet in thickness. Upstream from the exposed lake beds and especially in the wash south of the Darwin Hills the gravels are much thicker, and arroyos as much as 50-75 feet in depth have been carved. Dissection of the gravels on the west side of the hills is very slight compared to that on the east by reason of the bench of hard rock through which the stream flows at the south tip of the Darwin Hills. At this point is a "dry falls," 50-60 feet in height. Adjacent to the limestone hills not only the alluvium but also the lake beds are well cemented by calcium carbonate.

IGNEOUS ROCKS

Coso Granodiorite

The Coso granodiorite is batholithic in extent and underlies most of the plateau south and west of the Darwin Hills. A small area of this rock crops out in the southwest edge of the hills where it forms low rounded hills in contrast with the sharper relief of the limestones. Along the road to the Promontory mine it can be seen in intrusive contact with dark-gray limestones. Although thin sections from the rock of this area indicate it to be granite, the designation granodiorite is retained because it more nearly proximates the average composition of the batholithic material throughout the plateau. Megascopically it is a coarse-grained, light-colored, granitoid rock in which the principal minerals are quartz, feldspar, and green hornblende. Under the microscope most of the feldspar proves to be orthoclase or microcline. Biotite is common and such accessory and secondary minerals as sphene, apatite, chlorite, and epidote may be present. A few dark-green kersantite dikes cut the granite in the Darwin Hills.

Darwin Quartz Diorite

General Features. The formation name Darwin quartz diorite is here applied to the elongated stock which occupies the center of the Darwin Hills. All metallization is associated with this intrusive. The stock is about 3500 feet in its greatest width just northeast of Darwin. To the north and south it narrows and terminates in smaller isolated stocks, dikes, and sills. It ends within the hills and its total length is about five miles.

The drab brown color of the intrusive causes it to stand out nearly everywhere in strong contrast to the surrounding white silicate zone. The greater ease with which the intrusive weathers has caused it to form a lower interior belt of subdued topography surrounded by boldly outcropping stratified rocks. Variations in composition and texture within the igneous mass itself have also resulted in differential weathering. Thus, near the Defiance mine are several small knobs and ridges of quartz diorite standing out in otherwise subdued relief.

Composition and Variations. The stock as a whole displays considerable heterogeneity of composition, but for the most part these variations are only phases of the one intrusive. In nearly all of its phases the rock is medium-grained and nonporphyritic. It is normally a light colored, white or light-gray rock when fresh. Pinkish and greenish-gray types are also common. In general, variations in the intrusive range from quartz monzonite to diorite or gabbro. Nearly all of the phases with the exception of the gabbro are of the over-saturated type in which quartz is always present in essential quantities. In the quartz diorite or even the granodiorite the euhedralism of the plagioclase is the striking textural feature under the microscope.

In the over-saturated phases the ferromagnesian minerals are ordinarily not abundant. The most common ferromagnesian mineral is biotite. Hornblende and augite are decidedly less common and in many phases absent. Where the ferromagnesian content is high the mineral is most commonly augite.

Distribution and Origin of the Phases. The more basic phases of the rock occur in the north and south ends of the elongate stock. The change towards basicity is gradual yet very irregular. There is greater heterogeneity of phases and greater concentration of the melanocratic phases in the narrower terminations. Examples of the basic rock areas are well shown near the Christmas Gift mine where the rock is augite diorite or gabbro. Near the southern end of the Christmas Gift extension claim is a considerable area of very dark-colored rock which is almost entirely composed of augite with a little labradorite. In the southern end of the hills west of the Silver Spoon mine and south of the Promontory mine are areas of diorite or locally augitic rocks. These various types of rocks are not separate intrusions but different expressions of one magma.

There is little to indicate that the stock differentiated in place. Furthermore, except locally, reactions with the country rock do not appear to have influenced the composition. No regular border phase of more basic rock exists. Instead, phases appear to be due to original variations in the intruded material.

Perhaps the first intruded material was basic and later surges, intermediate in composition, pushed the basic material outward and toward the ends. As the stock grew, more acidic material continued to concentrate at the center.

Related Dikes. In places the border portion of the intrusive and the nearby contact aureole contain many dikes. Some of these are direct offshoots of the stock and cut only the country rock, while others are later and also cut the intrusive. The dikes are all more acidic than the main intrusive. In a few cases offshoots from the intrusive, where

traced outward, become increasingly acidic, changing sometimes to alaskitic or syenitic dikes. The syenite dikes are very common in the contact aureole between the Defiance mine and the Thompson mine. They are coarse-grained and composed almost entirely of orthoclase. The color varies between pink, green, and white. Whereas these and other dikes may have originated as magmatic dikes in the ordinary sense, the evidence suggests in some cases an origin by metasomatic processes. South of the George Washington shaft in the southern part of the hills, alaskitic material has spread in an anastomosing manner from stratification planes through several adjacent beds converting them completely to alaskite or quartz-orthoclase rock. In other places feldspar dikes appear to fray out and permeate adjacent walls in a manner suggesting replacement. This subject is treated more fully under igneous metamorphism. The subject of alteration of the intrusive is dealt with in the same chapter.

Basalt and Tuff

Many square miles of the Darwin plateau are covered by basaltic flows. The surface upon which this material was extruded was remarkably smooth, but it has since been broadly warped and block- or step-faulted. As a result the sheets are not everywhere continuous and in large areas they have been entirely removed by erosion. Furthermore, in downwarped or downfaulted areas much of the volcanic material has been covered by alluvium.

The northeastern edge of the Darwin Hills is covered by a basaltic sheet sloping 10°-15° toward the east. At the west edge of the sheet the thickness is about 20 feet, but eastward it thickens to 400-500 feet and four of five flows are distinguishable. Several thin isolated remnants of basaltic cap occur at distinct levels along the west flank of the hills, and while the uppermost of these is being exhumed by erosion, the lower patches are being covered by the outspreading alluvial apron. The pronounced difference in thickness of the sheet on the higher slopes of the Darwin Hills and to the east near Darwin Wash and Panamint Valley may be in part due to the lateral stripping of the flows in the higher area, but for the most part this difference is probably original. The difference in thickness and number of flows together with the occurrence of agglomeratic ejectamenta beneath the lavas in the lower course of the Darwin Wash suggest that the source of the volcanic flows in the northern part of the Darwin Hills was in the east, probably near the edge of the present Panamint Valley. The base of the basalt series is nearly everywhere characterized by loosely consolidated brown cinder beds. Near Darwin these are only a few feet in thickness, but toward the east they thicken considerably.

The extensive basaltic sheets of this region are all pre-basin and range faulting and were thought by Knopf to be probably of early Quaternary age. In this respect it is interesting to note the presence in this region of small basaltic cones which are younger than most of the basin and range faults. As in Owens Valley to the west many of these have had their position determined by the basis and range faults. To the east of the Darwin Hills along the flank of the Argus Range are two such cones. One of these has its locus along the Darwin tear fault and the other rose along one of the step-faults of the Argus Range.

STRUCTURE

SHAPE OF THE STOCK (See Figs. 4 to 9, inclusive)

The Darwin stock has a length of five miles and a maximum width of about two-thirds of a mile midway of its length. From the central part it tapers irregularly into narrow north and south tips which are only a few tens of feet wide. The general trend, N. 25° W., is parallel to that of the sedimentary formations into which it is intruded. In detail its original outline was rather irregular with many large and small protuberances and outliers. However, much of its present irregularity has been caused by subsequent cross faults which have offset the body in many places. In the northern part, the stock is characterized by many inliers of tactite which attest to the proximity and irregularity of its apex in this region.

In general the contact of the stock dips outward on both sides and so it widens in depth. On the west side the contact dips under the tactites approximately parallel to their stratification which is inclined, on the average, 50° to 60° westward. On the east side, especially in Lane canyon, the contact crosscuts the westward dip of the tactites. Toward the north and south ends of the stock the contact may conform to the west dip of the tactites in which places the stock would appear sill-like in cross-section.

FOLDS

The stock is intruded into steeply inclined beds of a folded Pennsylvanian series. The deformation of the Pennsylvanian rocks on the west side of the stock differs from that on the east side. The series on the west side of the stock is practically homoclinal and dips generally S. 65° W. at 50°. Two types of small local folds interrupt this general attitude of the beds. One consists of small, nearly upright and horizontal folds with axes parallel to the trend of the formation. Only two or three such folds occur in the series, the most noteworthy of which is the one near and parallel to the intrusive contact between the Defiance and Essex mines. The second class of local folds represents warps in the regional trend and, although the exact axial attitudes are difficult to determine, they are steep and usually at a considerable angle to the general strike of the beds. One such fold with axis pitching steeply westward occurs in the hills west of the Fairbanks mine. Another occurs high on the slope of Ophir Peak and can be seen from the highway approaching Darwin. These folds are like local knots in the otherwise even grain of the formation. It seems likely that the stresses which produced this second class of folds were different in direction from those which caused the first class of folds.

The beds on the east side of the stock are considerably folded. Immediately east of the contact the beds dip west into the stock, and and the first fold is usually encountered at a distance of 1000 to 2000 feet from the contact. In places this is a large anticlinal fold with limbs dipping 60° to 80°. Along the highway through the hills the folding consists of one anticline and syncline between the east contact of the stock and the alluvial edge, a distance of about one-half mile. If this simple folded belt is followed northward to the steep slopes of the hills east and southeast of the Christmas Gift mine, the folding resolves into

an intricate belt consisting of many closely spaced and nearly isoclinal folds. To the south of the highway along this same folded belt, which generally occupies the east front of the hills, are similar closely folded zones particularly in the vicinity of the Fernando mine and south of the Keystone mine. Immediately east of the Lucky Jim mine in the north end of the hills, another zone of close folds exists in which one of the folds is overturned and broken into a high angle overthrust to the east. In many other places the close folds are slightly overturned toward the east, and, if the isoclinal belts are viewed from the east front of the hills, the beds appear as a simple inclined series dipping steeply west. The eastern edge of this zone of close folds coincides approximately with the base of the hills. It seems best to consider the zones as incompetent folds superimposed upon the larger and broader folds of the region. There is some suggestion that these zones may be due to crowding of the stock during emplacement, but where the stock is widest and crumpling by shouldering of the intrusive might be expected to be the greatest, the folding consists of a single anticline and syncline. The zones of close folding parallel the narrower portions of the stock. Furthermore, since protuberances from the stock cut the limbs of the broader folds it is probable that most of the folding antedates the intrusion of the stock.

FAULTS (See Fig. 6)

Faults in the Darwin Hills and displacements thereon can be given the following age grouping: (1) post-Pennsylvanian and pre-intrusive, (2) post-intrusive and pre-mineralization, (3) post-mineralization and pre-lava sheets, and (4) post-lava sheets.

No faults of the first group have been positively identified in the district. It is probable, however, that the folding of the Pennsylvania beds prior to the intrusion of the stock was accompanied by some fracturing. A few of the faults described as post-intrusive in age may have had their inception before the intrusion. No evidence of the age relationship between the Darwin tear fault and the intrusive is available, inasmuch as the fault crosses the hills north of the stock. This fault may be older or younger than the stock. All of the displacements, however, on the smaller cross-faults which cut the stock are in the same direction as that on the Darwin tear fault. This may be evidence that the large fault is also later than the intrusion and hence belongs to the following group.

Faults of the second group are numerous and they are the structural feature which controls much of the metallization in the district. These faults, many of which were later mineralized to form fissure veins, developed after the consolidation of the stock, and may be divided into two subgroups. The first, which has proved to be of the most economic significance, are most numerous, shorter, and roughly normal to the intrusive contact. Practically all of their strikes fall between N. 54° E. and N. 65° E. Many show no measurable displacement. The maximum displacement is not over 100 or 200 feet. Some of the more persistent, such as the Lane and Standard Extension have lengths of 4000 feet. Most of them occur within the tactite zone around the intrusive and end at or shortly within the intrusive contact. Only rarely do they cut entirely across the stock as in the case of the Standard

Extension fissure. Where the direction of displacement is ascertainable the movement is dominantly horizontal with the north side moving relatively westward.

The faults of the second subgroup of this age are rather limited in their distribution and they strike N. 50°-70° W. These faults, few in number, constitute a shear zone which cuts through the entire stock in the first canyon and valley north of Lane canyon. (See Plate VII.) The direction of movement is the same as that on the previous group, but the displacement is greater and later. Both subgroups have been subjected to post-consolidation mineralization. The length of this zone of faults is 8000 or 9000 feet. Although they crosscut the strata on the east, to the northwest and on the west side of the stock they either die out or are taken up by strike slip along bedding planes. The northwesterly faults which displace the Lucky Jim vein belong to this group although they are not within the immediate zone.

The time period represented by the next group of faults, post-mineralization and pre-lava sheets, is great, several distinct periods of movement are suspected, but can not be definitely proven. Many of the fissures previously described show signs of movement after mineralization, and this movement in some cases appears to have had steep vertical components as evidenced by the slickensided gouge zones in many of the fissures. Some of this may represent minor adjustments which resulted from the block faulting following the lava eruptions in early Quaternary time.

A few faults which offset veins are also present. These faults have a trend which is more nearly east-west than the previously described fissures. (See Fig. 6.) They strike N. 70°-80° E. and the direction of movement on them was the same as on the previous two groups, that is, the north side shifted relatively west. A notable example is the Christmas Gift fault which offsets the Christmas Gift vein and oreshoot. The displacement on this fault near the mine is 300-400 feet. Another such fault crosses the ridge east of the Darwin Lead Company's camp and near the Rip Van Winkle shaft. Here the displacement is about 150 feet.

The largest fracture in the district is the Darwin tear fault. It cuts across the hills about 1000 feet north of the Lucky Jim mine. The fault strikes N. 75° W. and dips 75° S. This steep southerly dip is also characteristic of the above described faults offsetting the fissure veins. In most places it is a shear zone 200-300 feet in width. The striking manner in which the northerly trending beds are dragged parallel to the fault zone clearly indicates the direction of movement. The Darwin tear is of considerable extent and can be traced for several miles to the west of the hills where it gradually passes into a series of folds. About three miles east of the hills it causes the Darwin Wash to swing easterly along the belt of weakness. It is traceable to the top of the Argus Range where it passes beneath the basalt capping. It has a total length of at least ten miles.

Dr. Richard Hopper of the California Institute of Technology has since shown in the Argus Range that the Darwin tear fault has a considerable vertical component of displacement such that the north side has moved upward as well as westward.*

* Oral communication.

The Darwin tear fault appears to be the master fracture of the district and all of the smaller dislocations formed prior to the lava flows are in a way related to it. The direction of movement on the smaller faults in the hills is the same as that on the large tear. In strike the Darwin tear fault appears closely related to the northwesterly trending fractures described above. The age of the Darwin tear is rather uncertain. It may have had its inception prior to, during, or after the development of the fissure veins, but evidence is present that at least some of the movement is later than the lava caps of early Quaternary age. Near the top of the Argus Range the lavas appear to be somewhat deformed by late movements on this fault.

The fourth group of faults are large fractures which trend northwesterly and are to be identified as basin and range faults developed in Quaternary time. These were undoubtedly instrumental in forming the Darwin Hills. Their presence and position is in part based on physiographic evidence, but this is supported by the positions of certain remnants of basalt flows surrounding the hills. From several such remnants located at levels along the northwestern edge of the hills it appears that they have been elevated or perhaps tilted toward tht east along at least two parallel faults. On the east side of the hills the slopes are very steep, a fact which caused Knopf (1913) to postulate a fault along their base. He also noted that toward the north the fault must terminate because unbroken lava sheets cross the extension of the postulated fracture. The ruggedness of the eastern slope, especially in its southern part, is due to some extent to undercutting by the Darwin Wash, but that some of the relief is due to faulting appears evident from the position of the lake beds and the lava caps in the giant step faults in the Argus Range east of the Darwin Wash.

From the geologic map it is evident that the regional trend of the folded Pennsylvanian rocks determined the trend and elongate shape of the stock. The question arises as to the influence of the intrusion on the development of fracturing in the adjacent rocks. Ingersoll and Zobel[4] have supposed that the cooling and contraction of the rocks behind a heat wave advancing from the intrusive have been the cause of fracturing in which later mineralization takes place. Emmons[5] has pointed out that the fissures formed in the outer part of intrusives and in the adjacent country rocks are often formed by the forces of intrusion or the pressures generated during cooling.

At Darwin the displacements on the fracture systems are closely related to tectonic forces. The uniform direction of displacement and accompanying shearing attests to this fact. It may be true, however, that some of the fractures upon which displacements later took place owed their origin to forces developed by the intrusion. The answer to this could be obtained by the determination of the relative abundance of fissures adjacent to the stock as compared to their abundance and trend at a distance. Not enough detailed mapping has been done in areas outside of the Darwin Hills to determine whether the outlines of the fracture systems are extensive over the larger terrain of the plateau.

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[4] Ingersoll, L. R., and Zobel, O. J., An introduction to the mathematical theory of heat conduction: p. 129, 1913.

[5] Emmons, W. H., Relation of ore deposits and batholith: Ore Deposits of the Western States, p. 339, 1933.

ILLUSTRATIONS FOR REPORT

By VINCENT C. KELLEY

Geology and Ore Deposits of the Darwin Silver-Lead Mining District, Inyo County, California

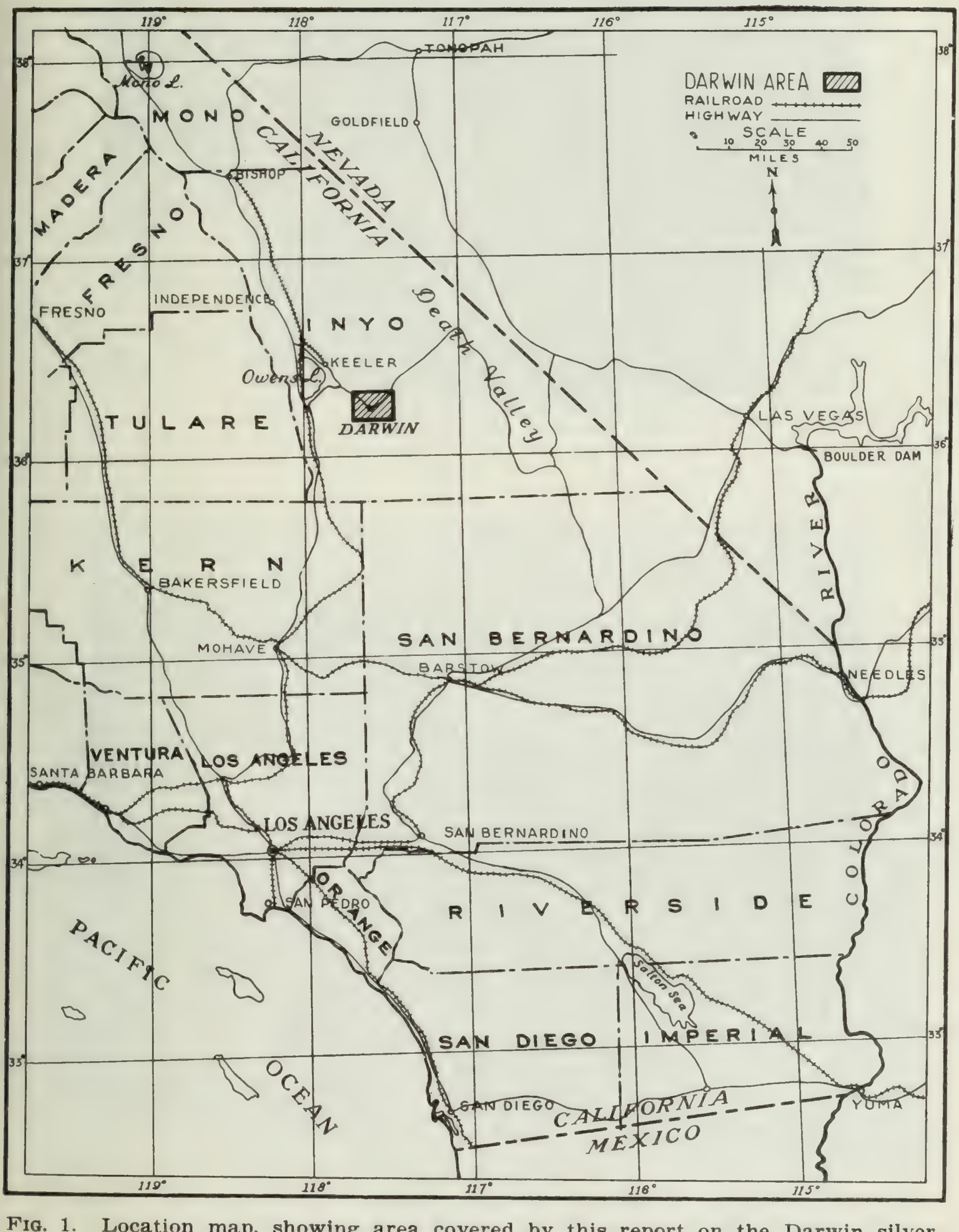


FIG. 1. Location map, showing area covered by this report on the Darwin silver-lead mining district.

FIG. 2. View across the Darwin plateau from the east over Panamint Valley. (1) North end of the Darwin Hills. (2) North end of the Coso Range. (3) Sierra Nevada. (4) Owens Lake. (5) South end of the Inyo Range. (6) Darwin Wash. In the foreground is the north end of the Argus Range.

FIG. 3. North end of the Argus Range and Darwin Wash from over Panimint Valley. (1) South end of the Darwin Hills. (2) Coso Mountains. (3) Sierra Nevada. The lava sheets capping the Argus Range on the left are equivalent to those in Darwin Wash at the right.

FIG. 4. Alaskite sill with offshooting dikes in tactite near the Defiance mine.

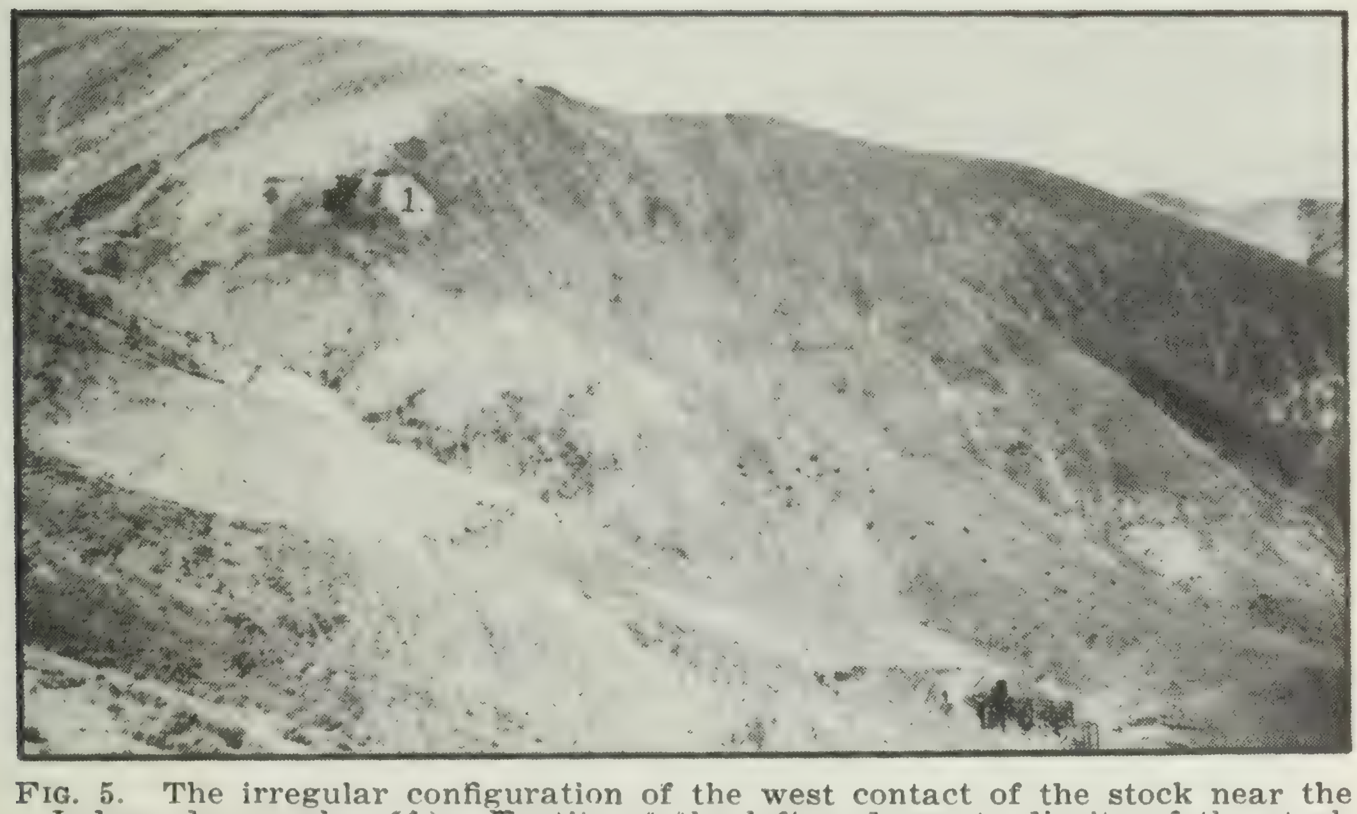


FIG. 5. The irregular configuration of the west contact of the stock near the Independence mine (1). Tactite at the left and quartz diorite of the stock at the right. Equipment at the Thompson mine can be seen at the lower right.

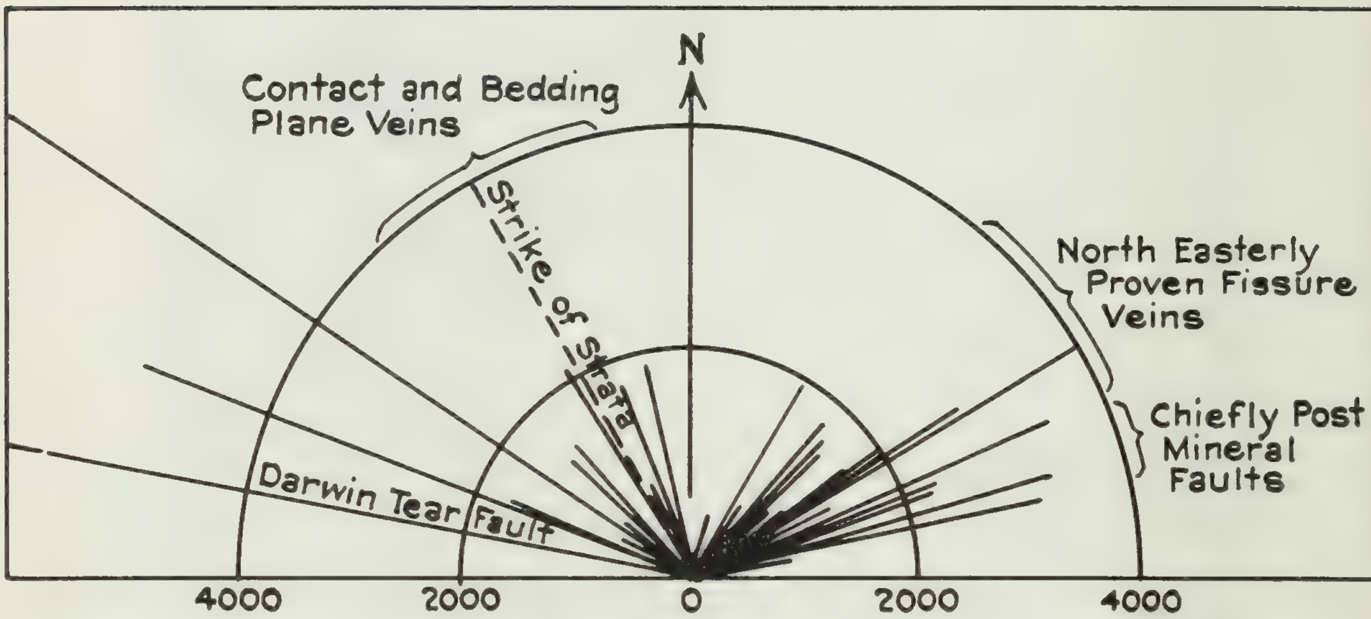


FIG. 6. Analysis of direction and magnitude of faults and of veins in the Darwin Hills.

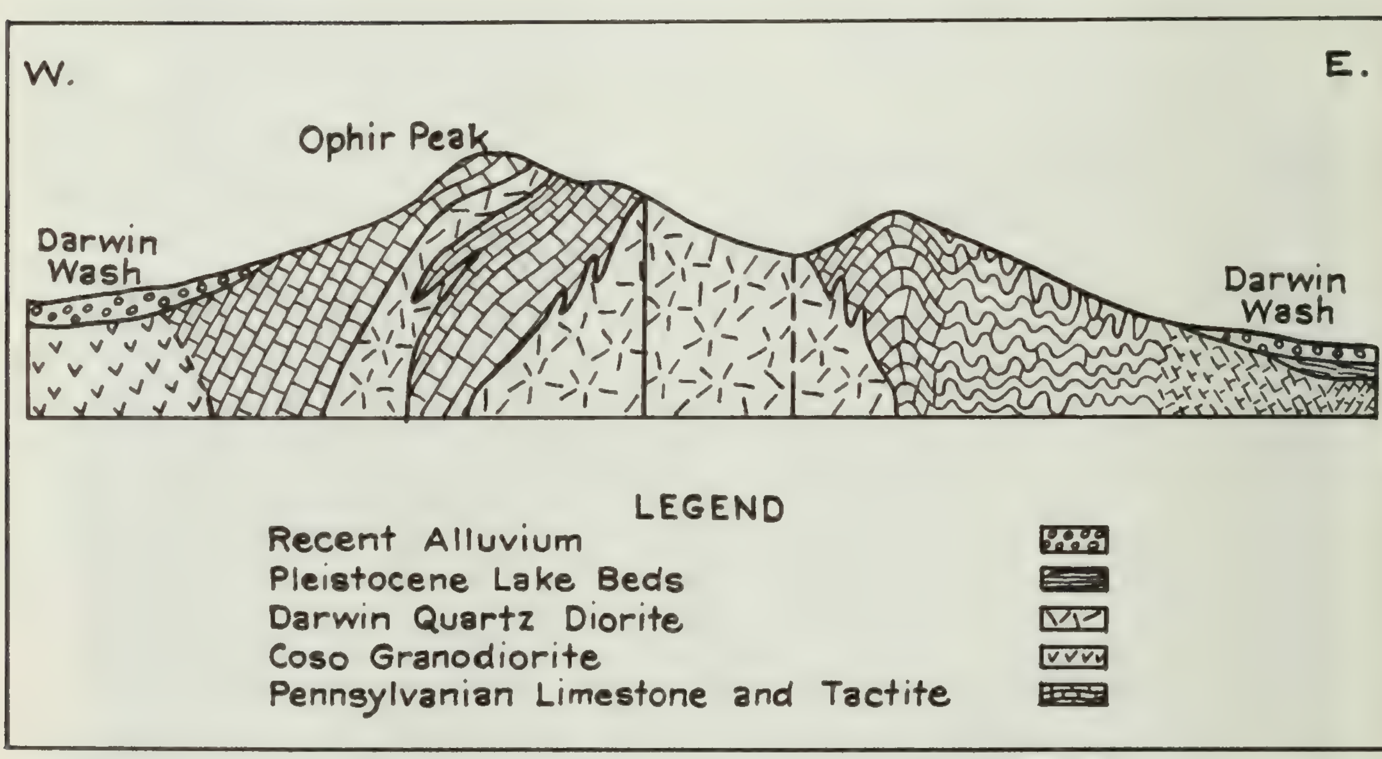


FIG. 7. Generalized structure section through the Darwin Hills near Ophir Peak.

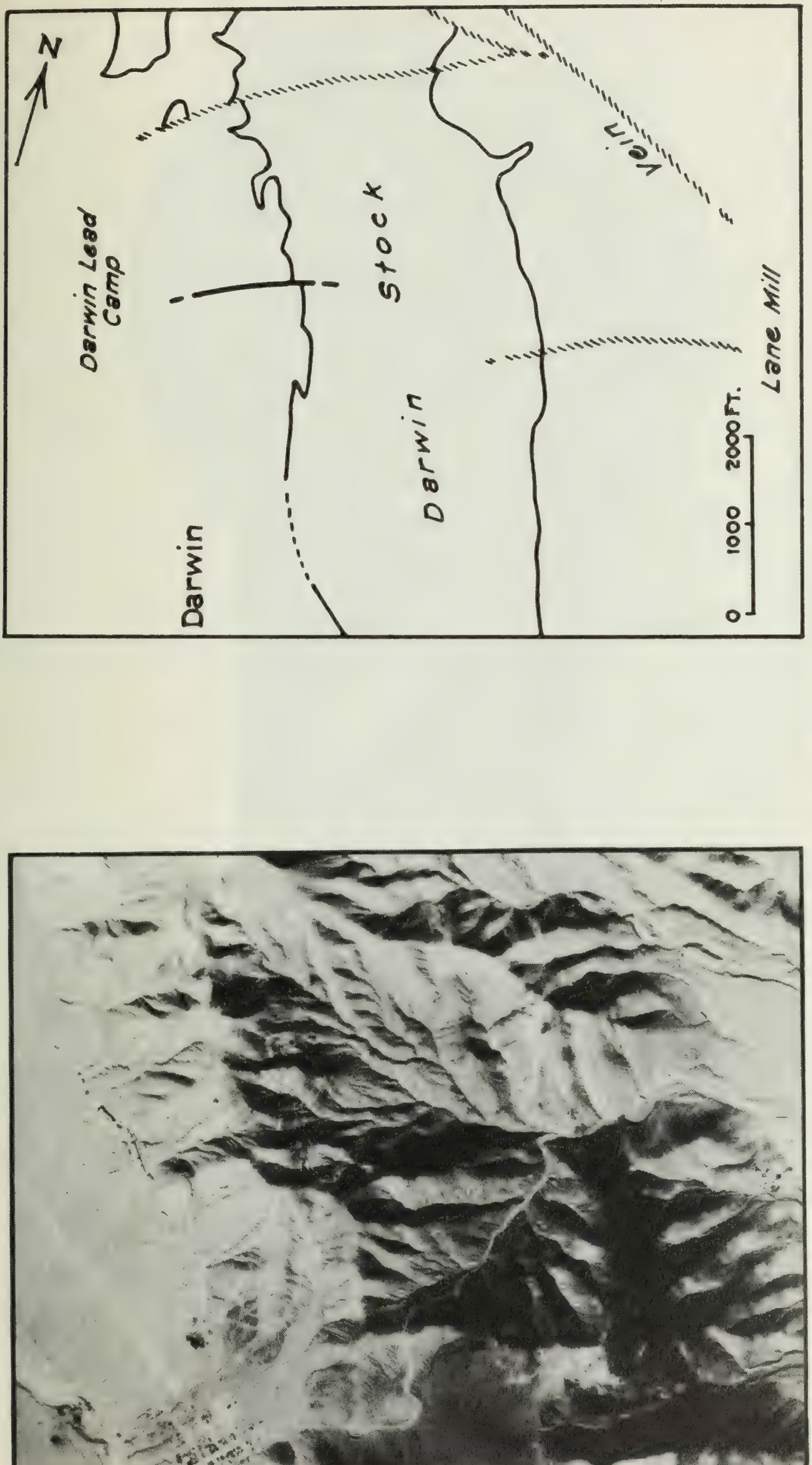


FIG. 8. Vertical air-view of Darwin Hills in the vicinity of the town and the Darwin lead camp. (Graphic explanation given in line-drawing.)

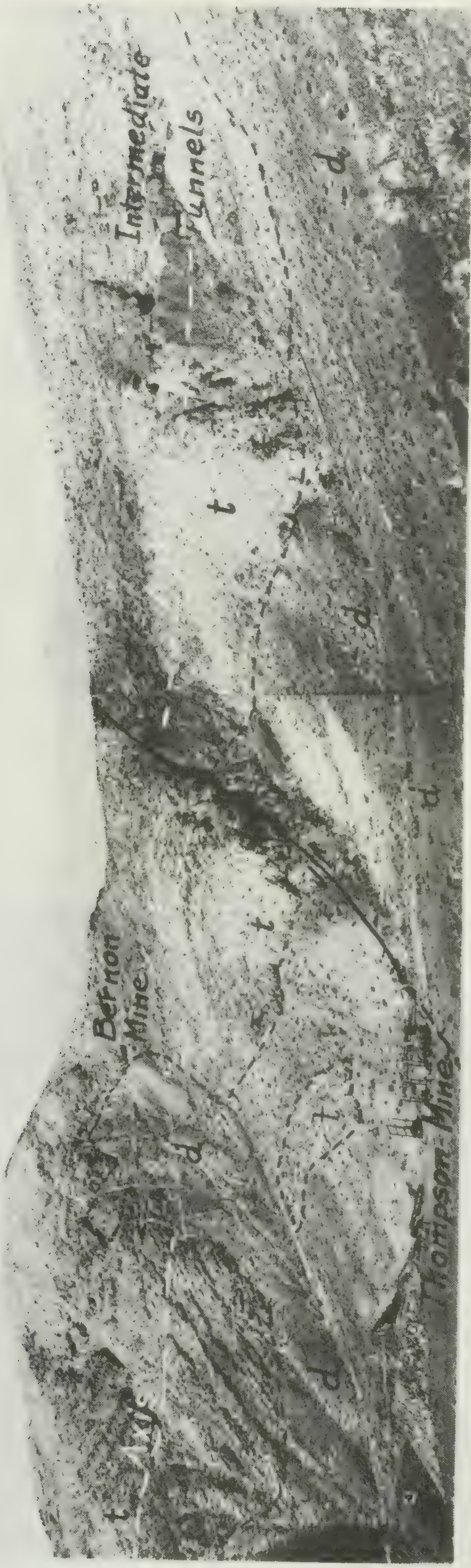


FIG. 9. General view of the contact of the stock (d) and the tactite (t) zone along the ridge between the Defiance and Independence mines.

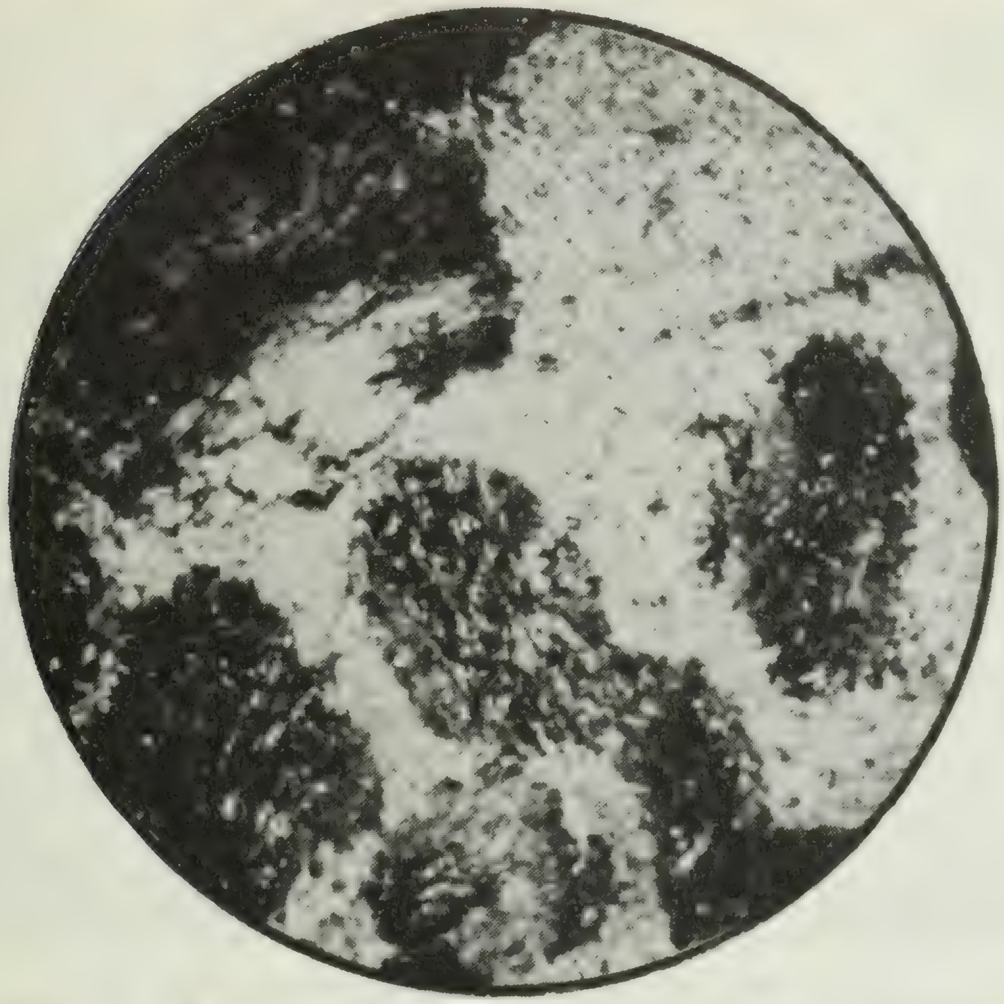


FIG. 10. Spots of wollastonite in fine-grained limestone. An early stage in the development of wollastonite tactite. Crossed nicols. Magnification 11X.

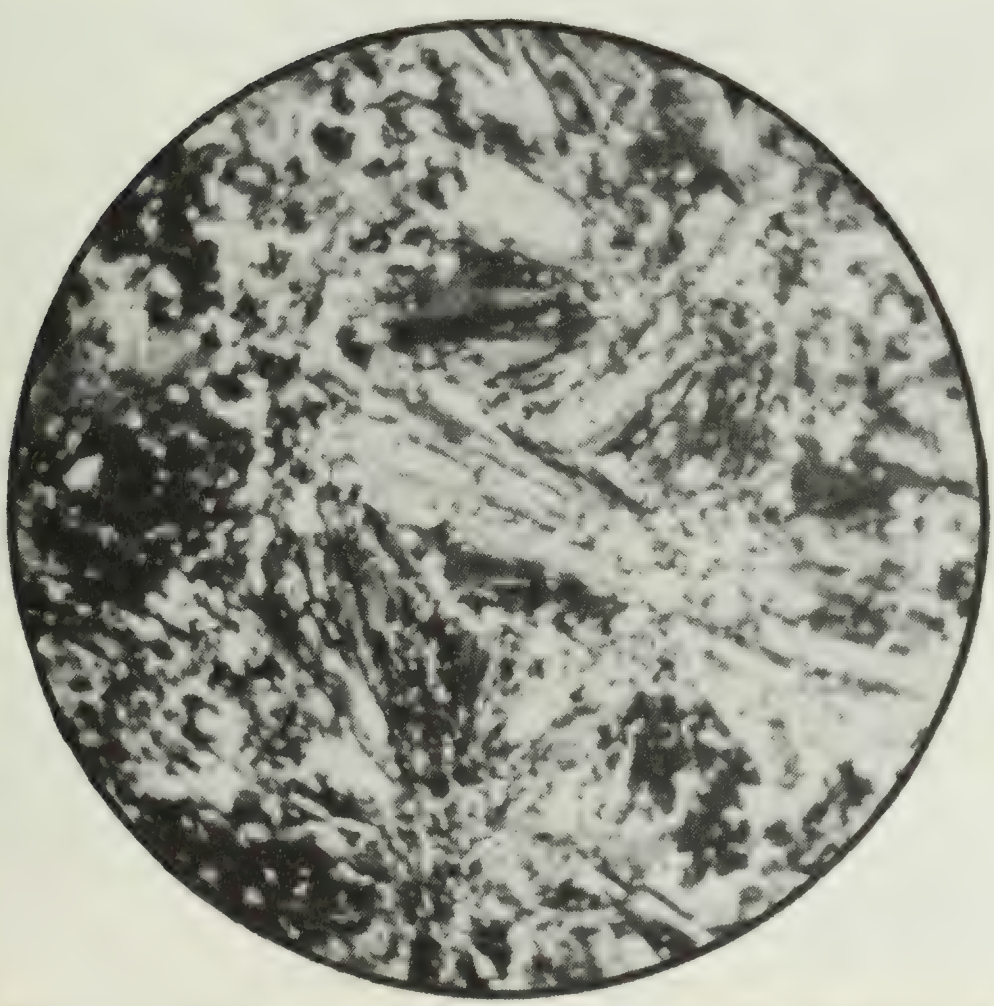


FIG. 11. Radiated wollastonite with interstitial calcite, a more advanced stage in the formation of wollastonite tactite. Crossed nicols. Magnification 20X.

FIG. 12. A wollastonite tactite. Crossed nicols. Magnification 20X.

FIG. 13. Large wollastonite crystal (wo) with twinned calcite (ca) and isotropic garnet (ga). Crossed nicols. Magnification 20X.

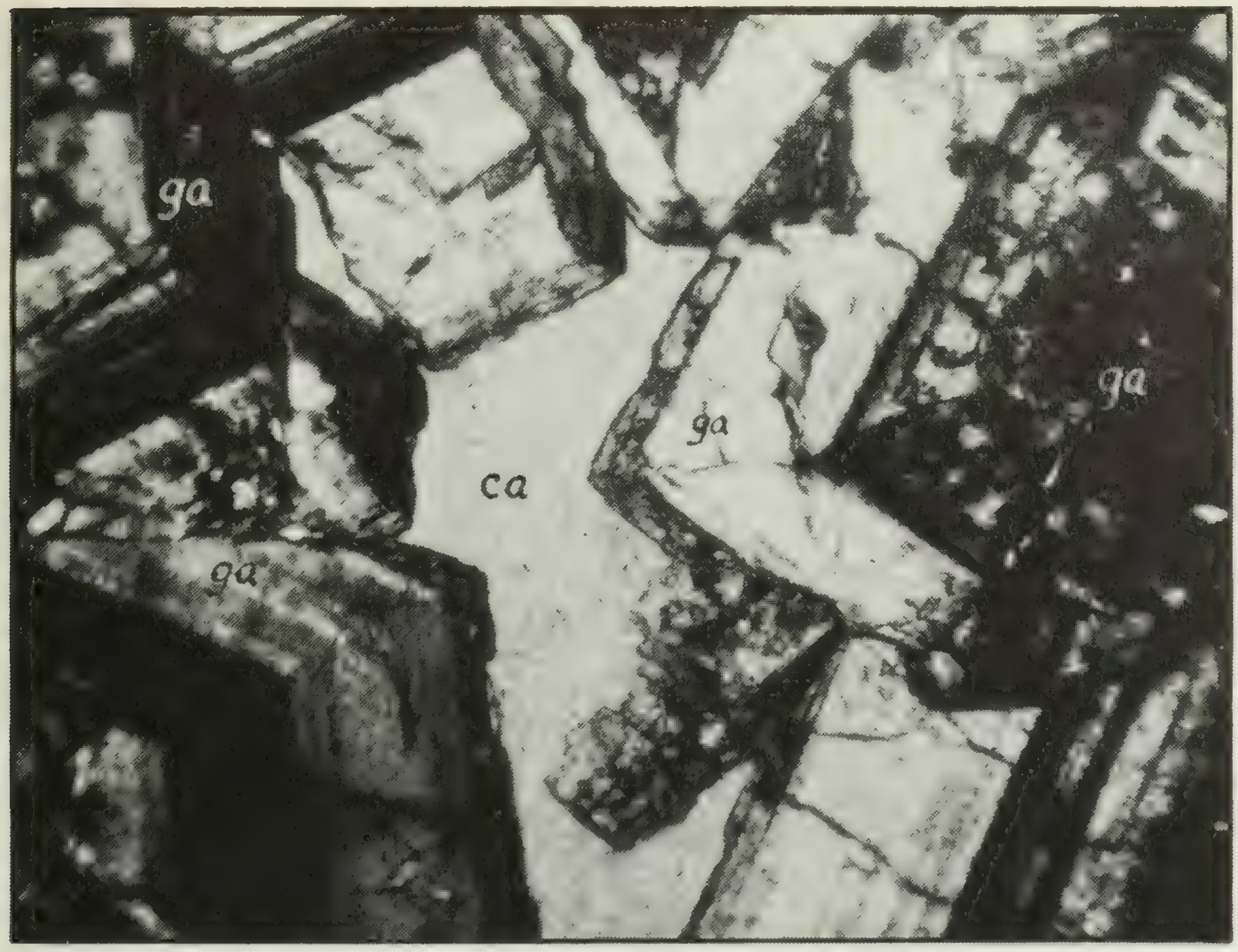


FIG. 14. Polysynthetic twinning in garnet (ga) with interstitial calcite (ca) from the tactite near the Thompson mine. Crossed nicols. Magnification 75X.

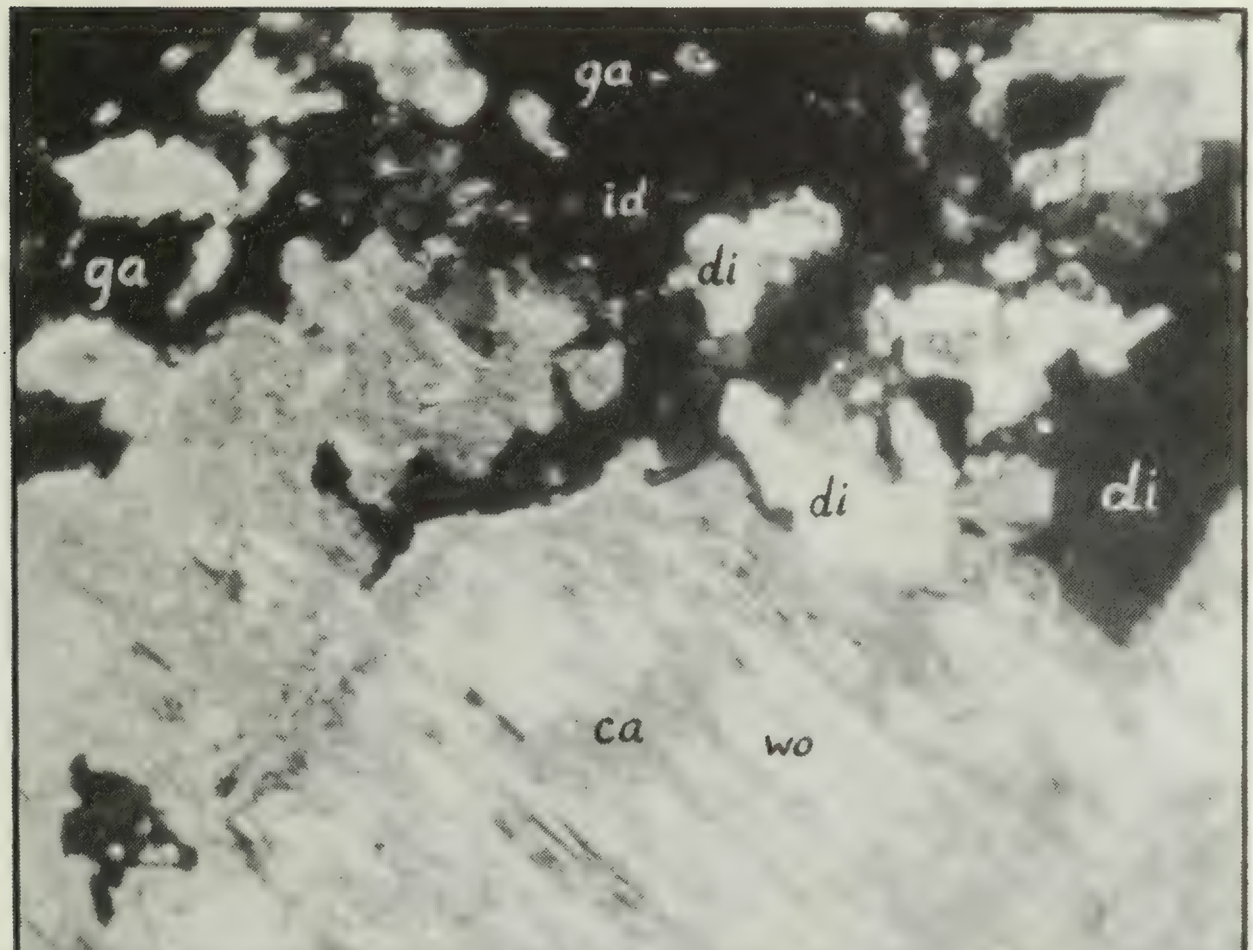


FIG. 15. Wollastonite (wo) replaced by garnet (ga) and calcite (ca) with some diopside (di) and idocrase (id). The shaded areas along the wollastonite cleavage and fractures are calcite. Crossed nicols. Magnification 75X.

FIG. 16. Evidences of metasomatism from the outer portion of the silicate zone, quartz and calcite veinlets cutting fine-grained quartzite and crystals of pyrite. Crossed nicols. Magnification 75X.

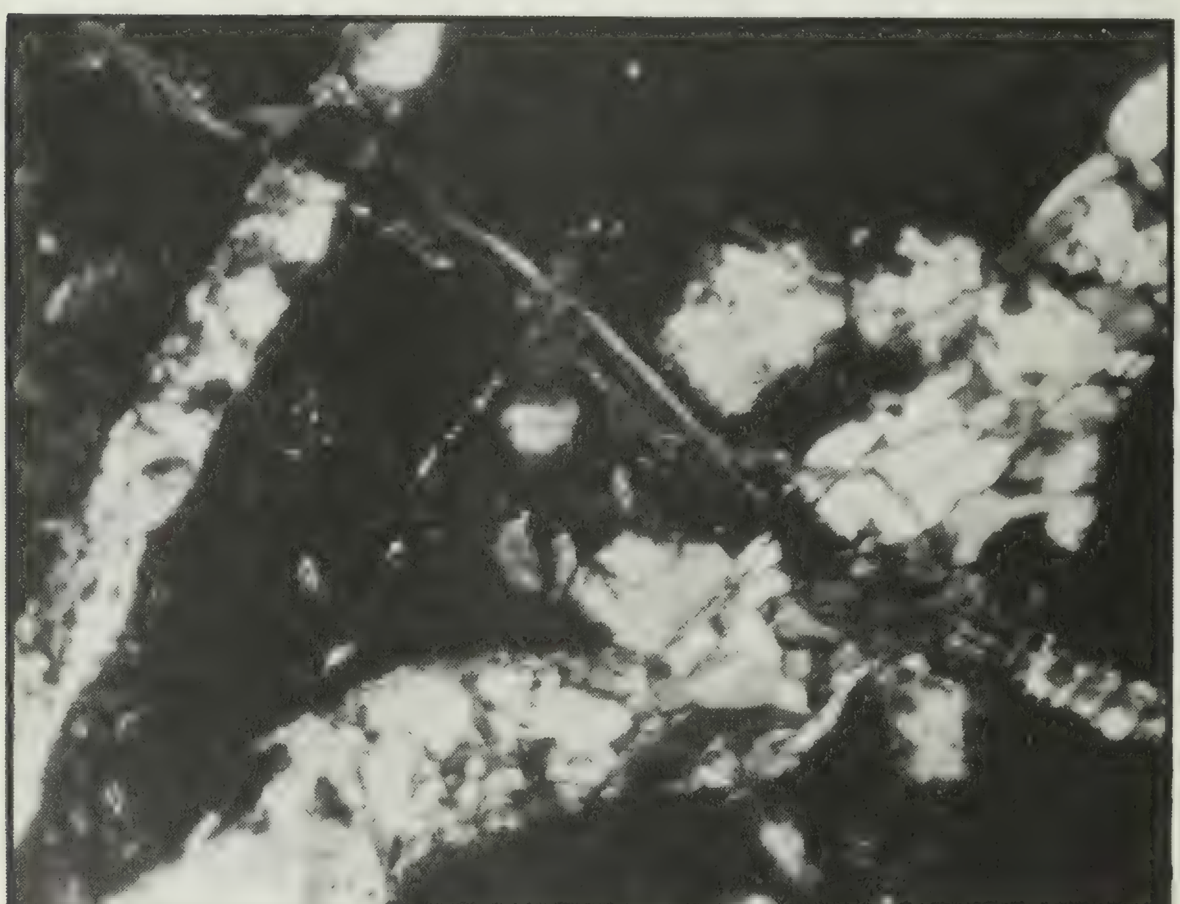


FIG. 17. Veinlets (large) of wollastonite and idocrase cutting impure partially silicated limestone or tactite (dark) and in turn cut by chalcedonic quartz veinlets. Crossed nicols. Magnification 75X.

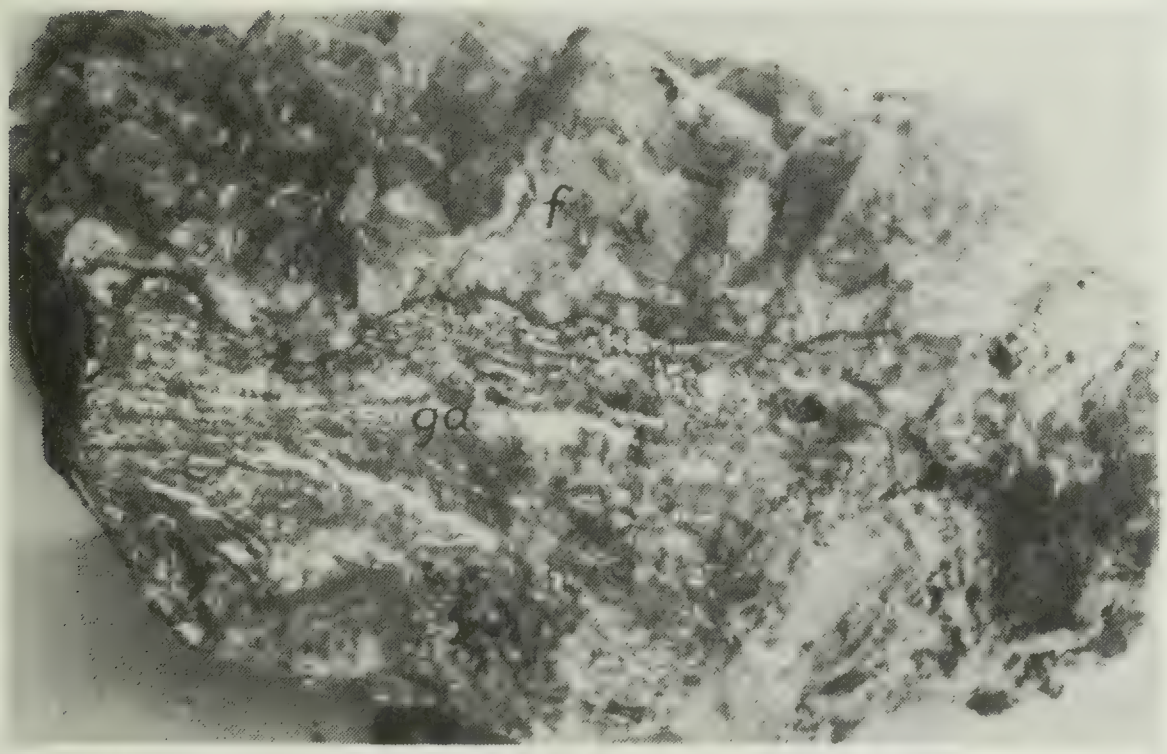


FIG. 18. Banded galena (gn) with fluorite (f). Note the dark seam of anglesite between the galena and fluorite. Defiance mine. Magnification 34X.

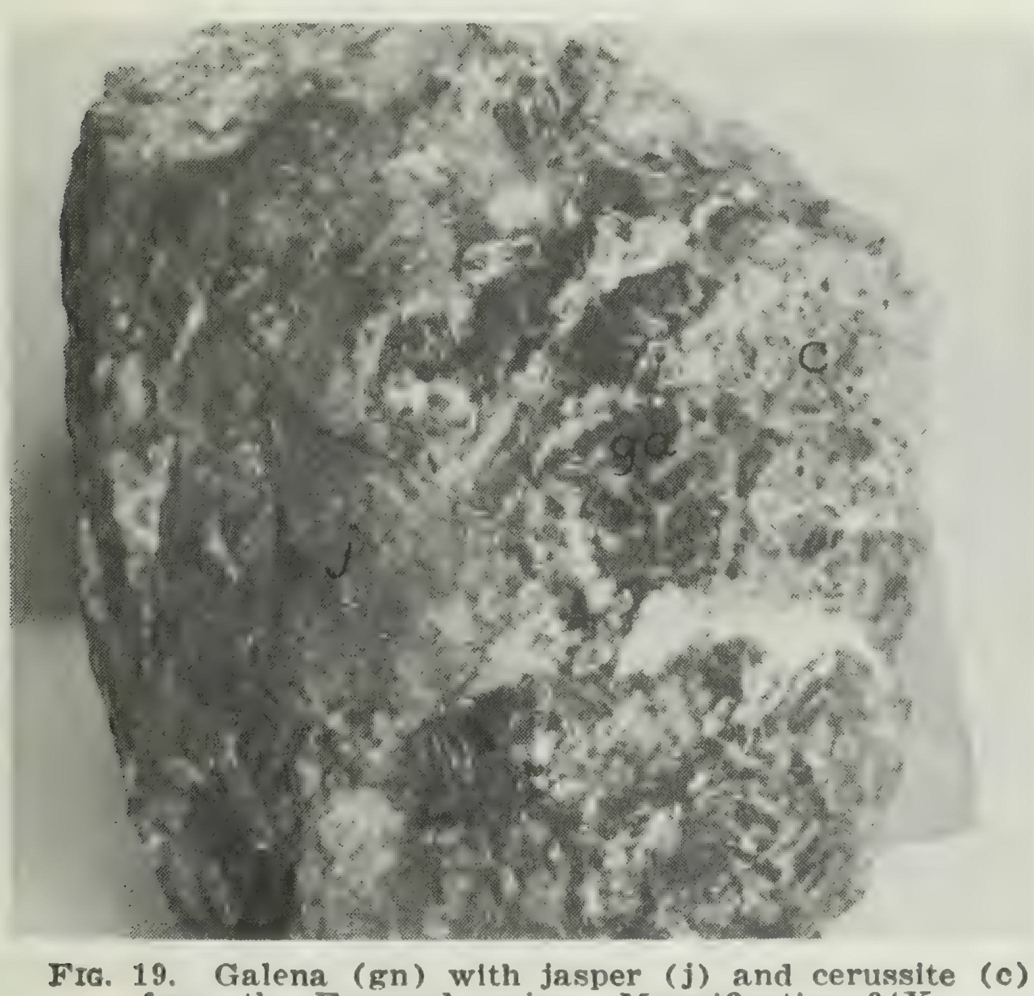


FIG. 19. Galena (gn) with jasper (j) and cerussite (c) from the Fernando mine. Magnification 34X.

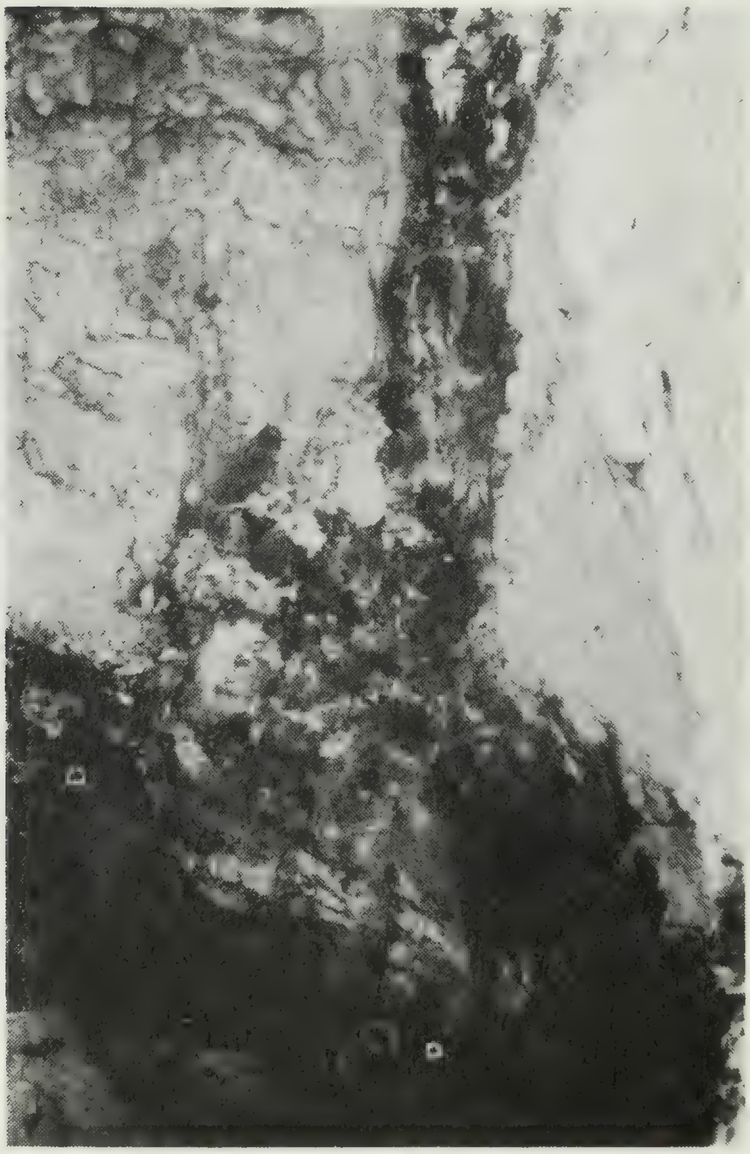


FIG. 20. Small jasper vein (1 ft. wide) in tactite (white). The vein cuts across a diorite dike (bottom) and forms a bunch on top of the dike. Prospect lode near the Christmas Gift mine.

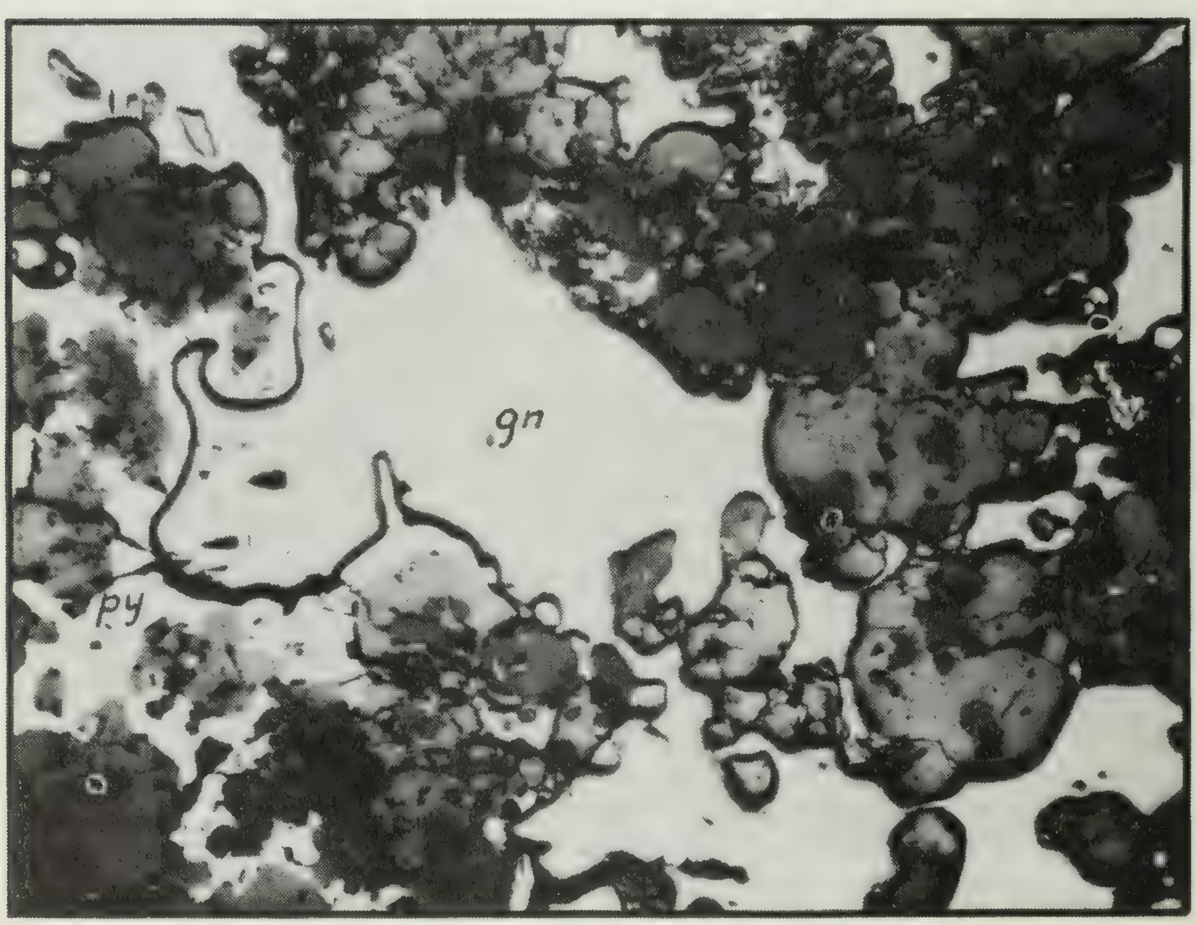


FIG. 21. Galena (gn) replacement of pyrite (py) in a gangue of garnet, calcite, and fluorite. Magnification 75X. Essex mine.

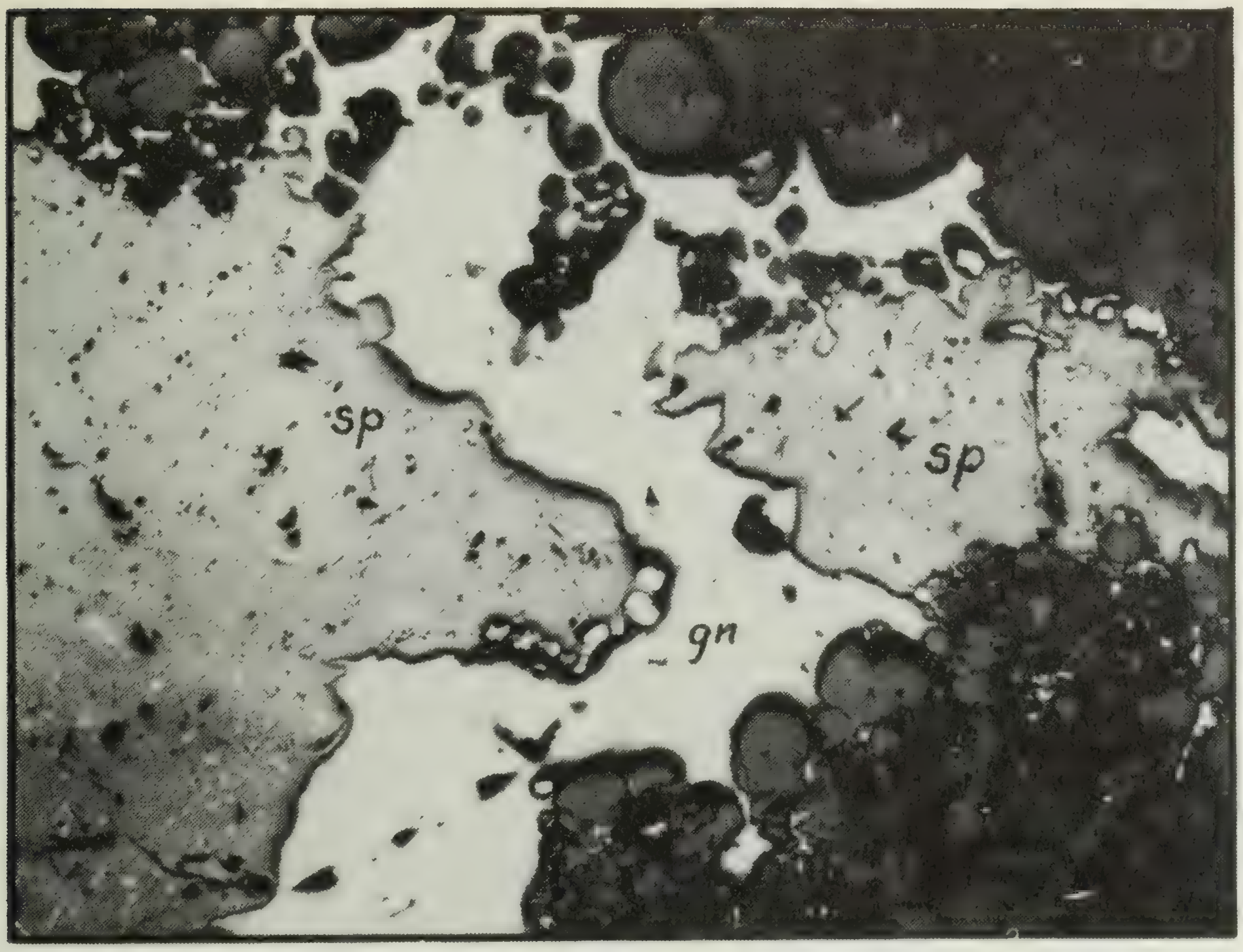


FIG. 22. Galena (gn) replacement of sphalerite (sp) dotted with chalcopyrite inclusions. Gangue is mostly garnet. Magnification 75X. Essex mine.

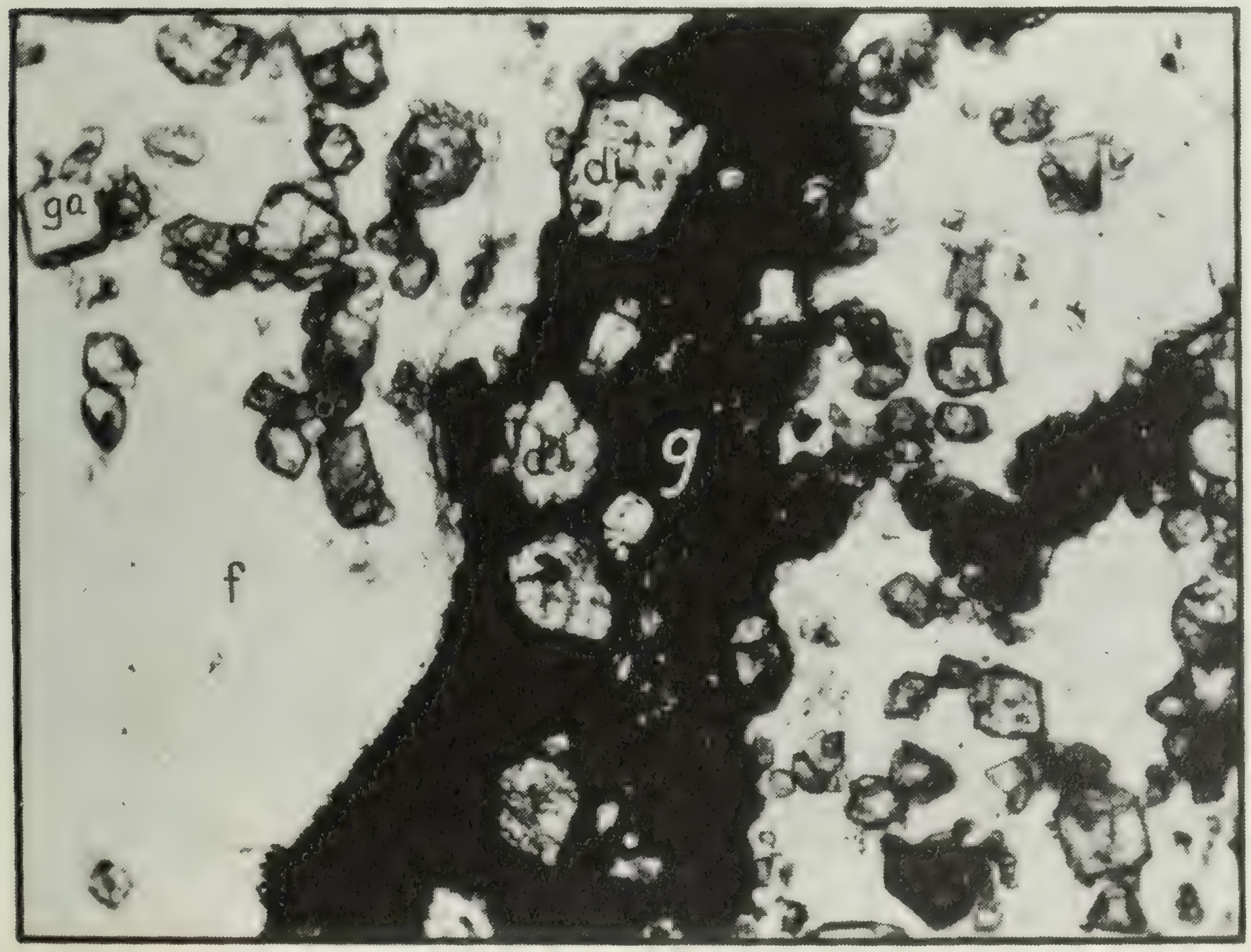


FIG. 23. Replacement of fluorite (f) by galena with residual metacrysts of diopside (di) and garnet (ga). Primary ore from the Essex mine. Plain light. Magnification 75X.

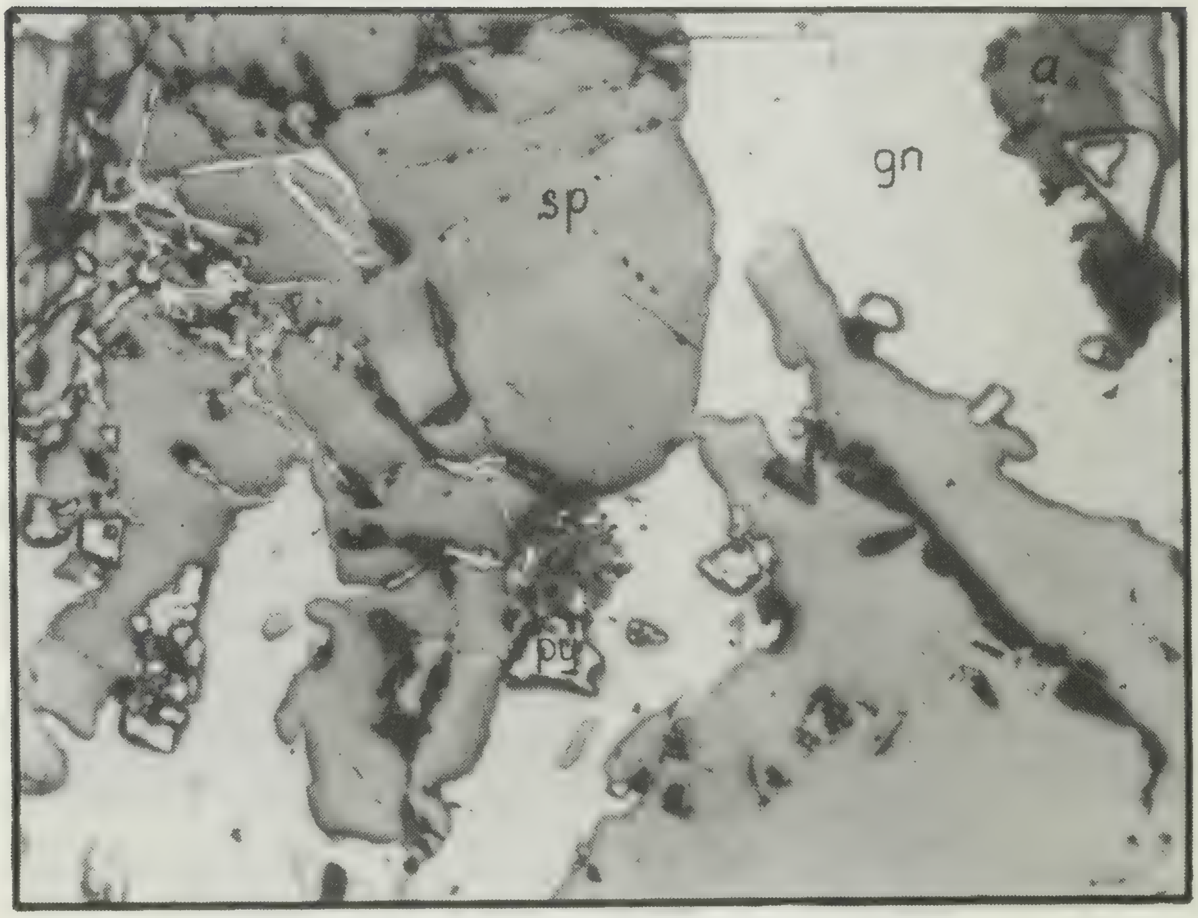


FIG. 24. Galena (gn) replacement of sphalerite (sp) and pyrite (py). Anglesite (a). Magnification 75X.

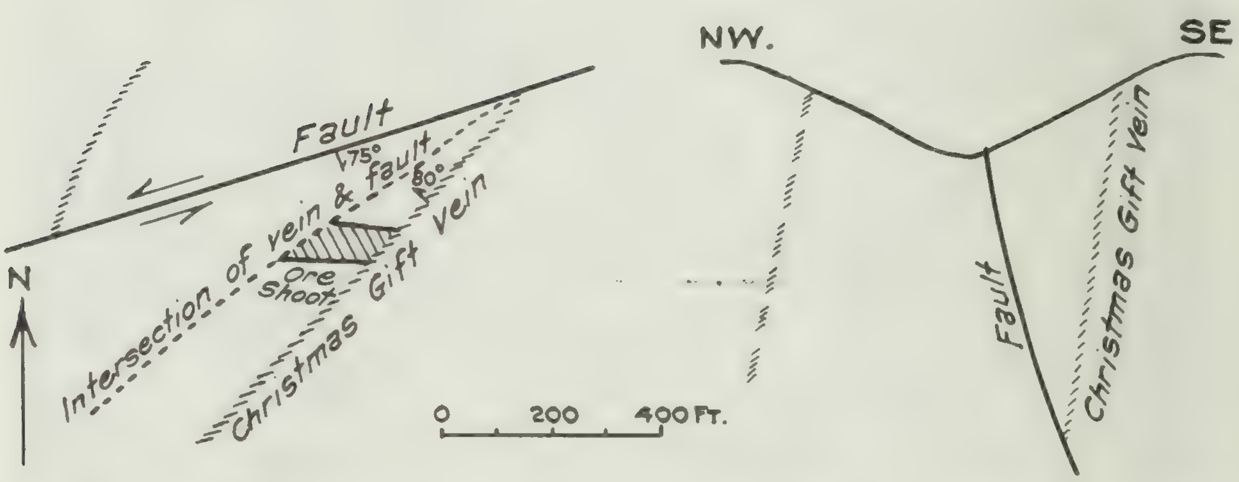


FIG. 25. Diagrammatic section (right) and plan sketch (left) of Christmas Gift vein and fault showing rake of ore shoot.

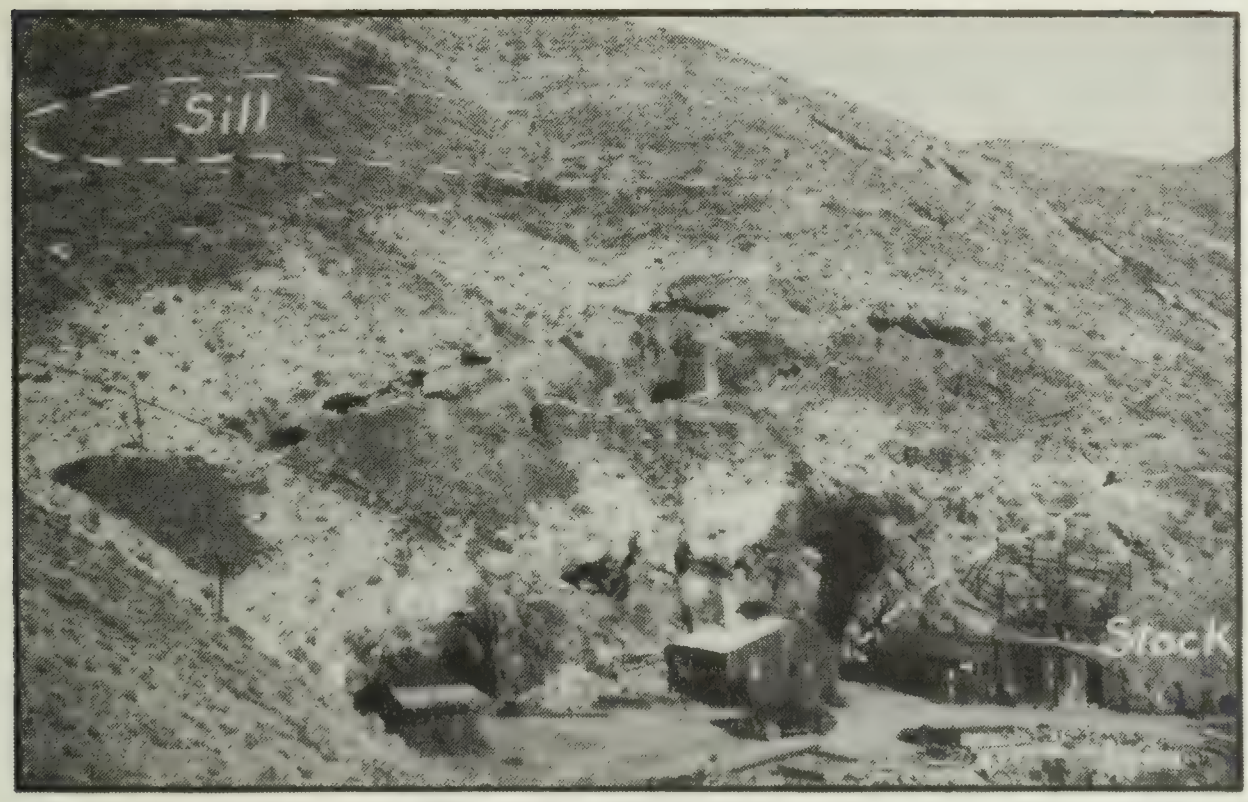


FIG. 26. View of the Defiance mine showing the lower and upper ore bodies lying between the stock in the foreground and the sill above the white tactite wedge in the center of the picture.

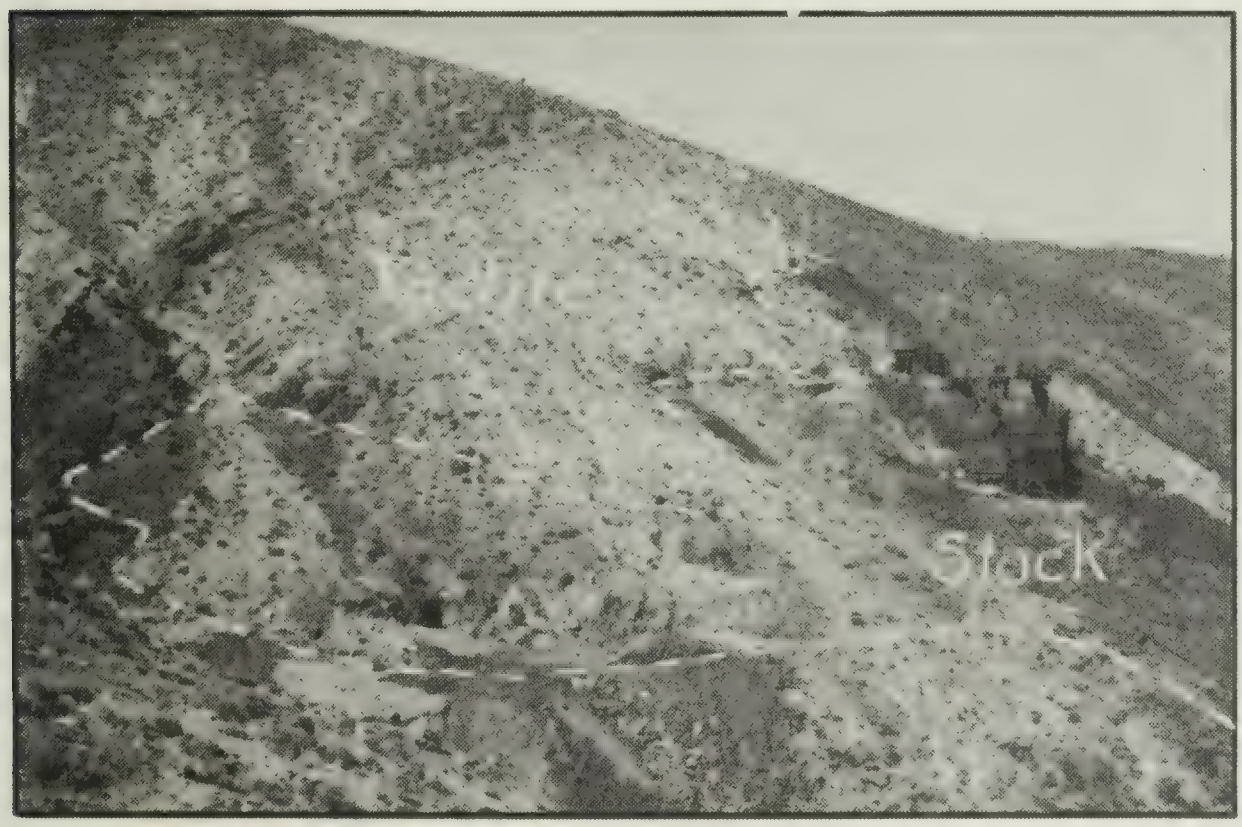


FIG. 27. View of the Independence mine (right of center) and the Essex mine (lower left). The prominent white tactite outcrop in the center of the picture lies as a blanket over the large Independence orebody within the ridge and a part of which may outcrop in the dark area in the extreme left in the picture.

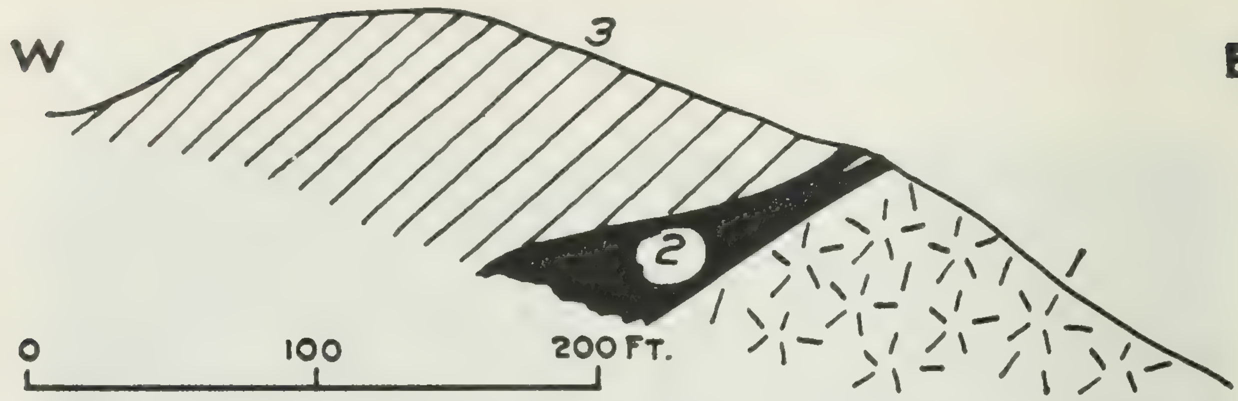


FIG. 28. Diagrammatic section through the Independence orebody. 1. Quartz diorite. 2. Orebody. 3. Stratified tactite.

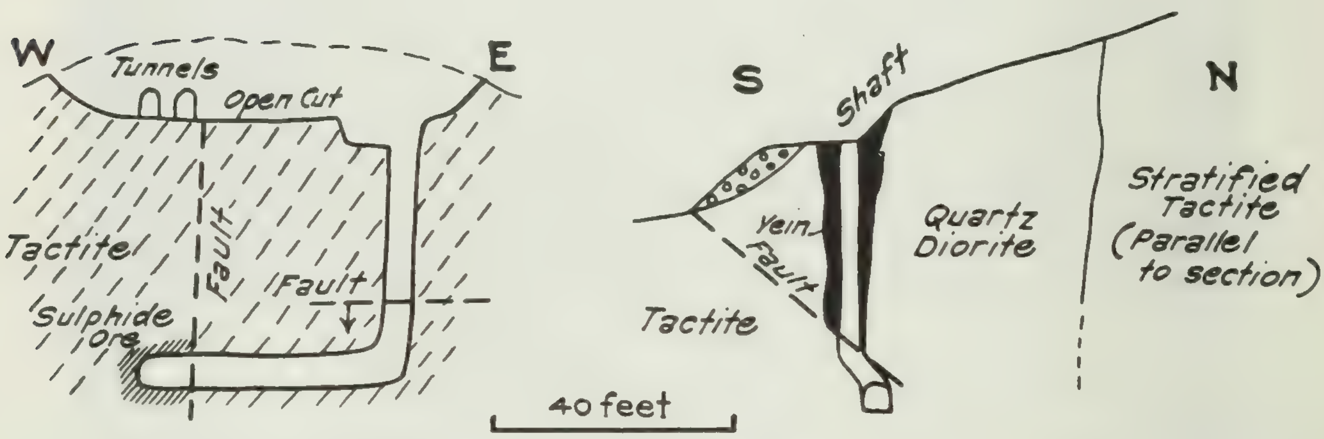


FIG. 29. Diagrammatic sections through the Essex orebody. Left, parallel to the vein. Right, across the vein.

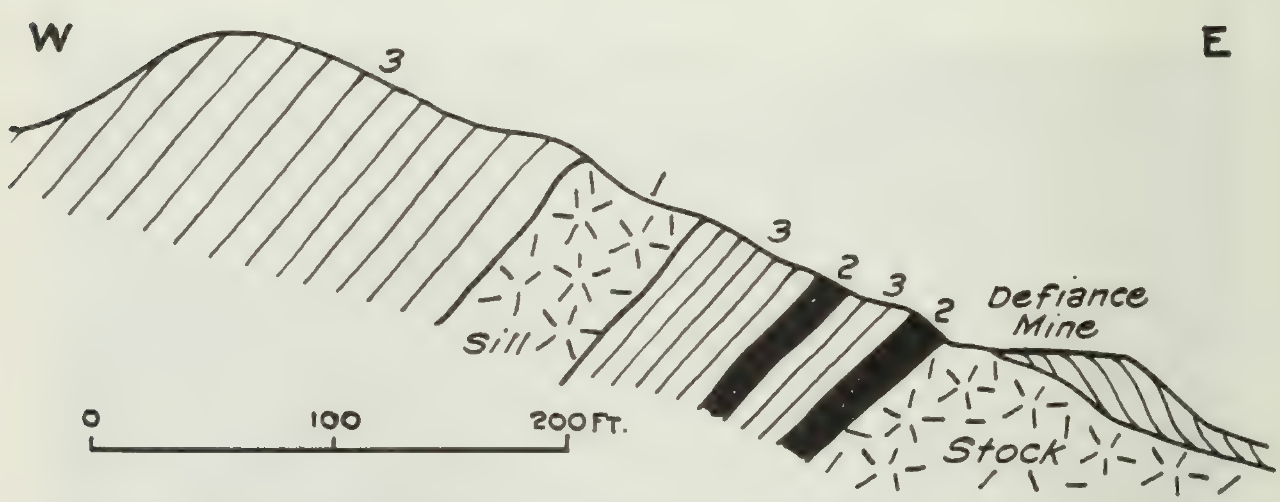


FIG. 30. Generalized section through the Defiance orebodies. 1. Quartz diorite. 2. Orebody. 3. Stratified tactites.

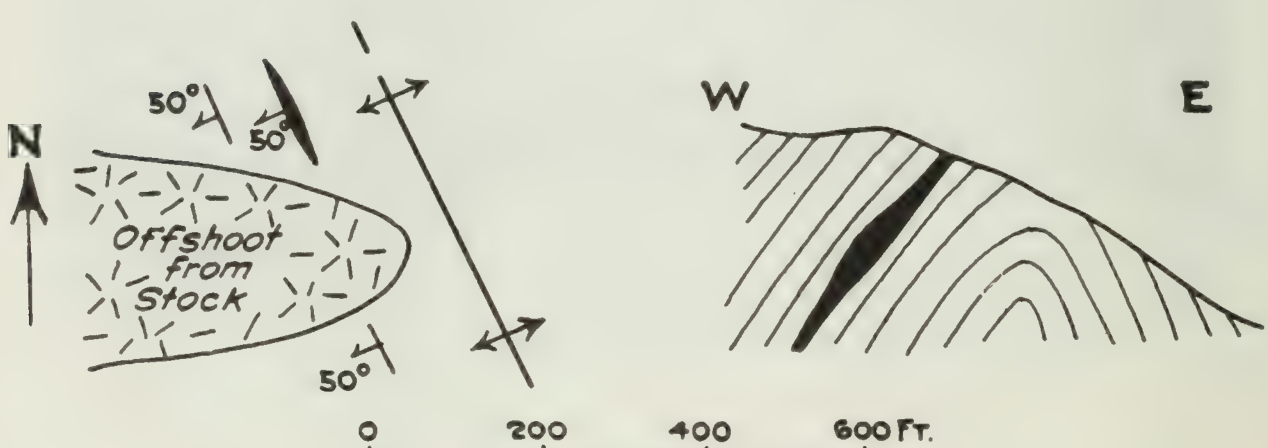


FIG. 31. Plan (left) and section (right) of the Custer orebody showing its relationship to the stock and the structure of the tactite.

It might be noticed in favor of the tectonic character of the fracture systems that Knopf and Kirk (p. 21, 1918) found much the same trend of fractures on a larger scale in the Inyo Range. The general conclusion reached for the Darwin Hills is that the fractures and especially the subsequent movements thereon are not related to intrusion, but rather to tectonic forces.

In summary, the structure of the Darwin Hills is characterized by a considerably folded series of impure Pennsylvanian limestones intruded by an elongated stock which occupies the center or core of the range of hills. Although parallel to the strike of the formations the stock transects the west limb of a large fold in depth. The major axis of this large fold is generally about 1000 feet east of the stock. The east limb generally occupies the steep eastern slope of the hills. It is considerably crumpled into a series of closely spaced nearly isoclinal folds. A system of northeast and northwest fractures transverses the whole. The common direction of movement on all of these has been westward on the north side. The total affect of the displacements on all of the fractures has been to move the tip of the elongate stock several hundred feet west of its original position with reference to the south tip. Uplift along faults roughly bounding the hills slightly tilted the range above the plateau in Quaternary time.

IGNEOUS METAMORPHISM

ALTERATION OF THE SEDIMENTARY ROCKS

General Character

Since most of the minerals of the silicate zone about the intrusive are calcium silicates, the term *tactite,* proposed by Hess,[6] is applied herein to these rocks as a whole. Hess applied the term to calcium silicate strata or rock affected by magmatic emanations. The term *hornfels tactite* is used for the fine-grained or aphanitic tactites. Other descriptive terms are prefixed to the name, such as wollastonite tactite or garnet-diopside tactite.

At Darwin the tactites are whitish, medium- to fine-grained, stratified rocks. The width of the tactite zone about the stock varies from a few tens of feet to nearly 2000 feet. The outer limit of the zone is roughly determinable by the extent of bleaching of the original rocks. An aureole about 1000 to 1500 feet in width is most common. The retained stratification is the principal existent structure. Although in many places the tactite is fine-grained or aphanitic, large areas of stratified tactite composed of visibly felted aggregates of wollastonite occur. Locally, decidedly coarse textures are found. Light green garnets one to three inches in diameter imbedded in wollastonite are common, and one garnet a foot in diameter was found south of the Defiance mine. On the prominent white ridge south of the Lucky Jim camp are areas of tactite in which wollastonite prisms three to six inches in length are abundant associated with garnet and considerable idocrase. Idocrase crystals attain dimensions of one to two inches. In general, the coarser the texture, the less is the mineral diversity. Coarseness of grain, except in a broad way is not related to proximity

[6] Hess, F. L., Tactite, the product of contact metamorphism: Am. Jour. Sci., vol. 48, pp. 377-378, 1918.

of the igneous contact. Thus, at the Defiance mine the tactite at the igneous contact is dense, fine-grained, white rock, while westward from the contact to the top of the ridge there are many beds of medium and coarse-grained tactite.

Minerals and Textures

Wollastonite. Wollastonite is perhaps the most abundant mineral of the silicate zone. It occurs in felted masses which may comprise bed after bed of the tactites over considerable areas. Locally, usually near the igneous contact, wollastonite forms in large reticulating prisms associated with small quantities of garnet or idocrase. (Fig. 15.) In the outer part of the tactite zone it occurs in small radiating groups imbedded in fine-grained calcite or limestone in such a way as to make it apparent that its formation was the first manifestation of the silication process. (Figures 10 and 11.) Even in this initial stage of silication it is common to find small amounts of idocrase associated with the wollastonite. Wollastonite also occurs in veinlets with garnet and idocrase cutting a matrix of hornfels tactite or in some cases pure limestone. (Figures 16 and 17.) Thus it is common to find wollastonite in the groundmass and in veinlets cutting that matrix.

Garnet. With the exception of wollastonite, garnet is the most conspicuous mineral of the tactites. It is typically a light-green garnet. Qualitative tests indicate approximately equal quantities of aluminum and iron in addition to calcium. It is, therefore, most generally a mixture of grossularite and andradite molecules. By far the greatest percentage of the garnet is birefringent, showing remarkable zoning and polysynthetic twinning. (Fig. 14.) In addition to the regular arrangement of the birefringent parts, it often shows wavy and irregular anisotrophism. Also it often shows two stages of growth in which the core may be greenish and the periphery colorless or vice versa. Perimorphs of garnet are very common in calcite. Some of the totally isotropic green garnet is probably almandite. Rarely a little dark brown or black garnet is found, and it also is isotropic.

Garnet is widespread throughout the zone, but the larger and more perfect crystals occur near the igneous contacts. In some places massive garnet zones a few feet in thickness border the immediate contacts. Garnet is found in association with all of the silicate zone materials, but most commonly with calcite which occurs not only between the garnet crystals but in veins replacing them. Garnet replaces wollastonite and in some instances appears to form pseudomorphs after the latter mineral. Garnet also forms veinlets cutting a matrix which may include earlier garnet among other silicate minerals. Locally garnet develops as a post-fissuring silicate mineral cementing or replacing earlier silicates, calcite, or igneous rock. Small crystals of tourmaline or sphene are commonly found included in the garnet.

Diopside. Diopside is practically the only pyroxene present. It is abundant in fine-grained tactites with wollastonite, garnet, calcite, and other minerals. Poikiloblastic diopside and sometimes hedenbergite in orthoclase are common near the contacts. Diopside is occasionally found replacing wollastonite, but it did not continue to form as long as garnet.

Idocrase. Idocrase, although not as abundant as the preceding minerals, is nevertheless common at Darwin. It occurs in dense green masses closely resembling garnet and in euhedrons in calcite or wollastonite. Calcite is nearly always present veining the idocrase. Under crossed nicols the Darwin idocrase shows strikingly anomalous Berlin blue or green colors. Polysynthetic twinning and zoning similar to that in the garnet are common. Idocrase replaces wollastonite and is idioblastic against it, but in contact with garnet the latter mineral is euhedral. The large metacrysts of idocrase are found only near the igneous contact, but disseminated grains and small veins are found in the outer portion of the tactite zone associated with wollastonite.

Epidote. Epidote occurs only sparingly in the tactites proper. It is mostly confined to the immediate contact where it forms in veins replacing orthoclase in dike rocks or in the intrusive proper.

Orthoclase. Orthoclase is a very common mineral in the tactites, especially in the areas of more intense alteration or near the igneous contact. Likewise, border phases of the intrusive are sometimes unusually rich in orthoclase, enclosing poikiloblastic garnet, plagioclase, hedenbergite, or biotite. Orthoclase is found intimately intergrown with wollastonite, diopside, garnet, and calcite in the hornfels tactites. Its occurrence in dikes anastomosing through the tactites has already been mentioned. Orthoclase is also found lining post-consolidation fractures in the intrusive, indicating its late deposition in part.

Calcite. Calcite is the most widespread mineral of the tactite zone. In many of the tactites, both coarse and fine, it forms a matrix with lesser quantities of orthoclase, plagioclase, or quartz for the more idioblastic minerals such as wollastonite, garnet, or diopside. Coarsely crystalline, marmorized limestone is not exceedingly common in the tactite zone. More common are remnants of blue-gray limestone in which the calcite is clouded by argillaceous impurities. Late calcite veinlets in all other minerals are very abundant.

Quartz. Quartz is only sparingly present in the silicate zone. Under the microscope quartz is sometimes found intergrown with calcite scattered through the garnet. Occasionally it is found interstitial to euhedral aggregates of garnet. Also small veinlets of quartz are found cutting most of the silicate minerals. Many of these veinlets are chalcedonic. As will be mentioned later, quartz is more abundant as a post-fissure mineral.

Plagioclase. Plagioclase is very abundant in some of the tactites. Practically all of the plagioclase seen in the tactites is untwinned oligoclase. It is for the most part quite fresh and closely resembles quartz, for which it is easily mistaken, by reason of the fact that the two are not usually found together. The oligoclase occurs in a much sutured intergrowth with calcite, the latter mineral being the more abundant of the two. Idioblastic and xenoblastic garnet is scattered through both minerals and oligoclase appears to replace the garnet in several instances. A noticeable feature of the oligoclase-calcite tactite is the absence of wollastonite. Thus, in one petrographic study made normal to the igneous contact, thin-sections of the first 100 feet show abundance

of wollastonite and some garnet, diopside, and calcite, but no oligoclase. Sections of the next 100 feet reveal considerable oligoclase with calcite and garnet as mentioned above, but no wollastonite. Still farther away the situation is reversed again. Since this profile was taken across the strikes of the tactites it seems likely that the original composition of the sediments was the controlling factor. However, it appears likely that the oligoclase and wollastonite are incompatible. The case is undoubtedly analogous to the observations made by Harker [8] that anorthite and wollastonite combine to form grossularite and quartz, although in the case of oligoclase it is not quite clear what becomes of the albite molecule. A small quantity of twinned poikilitic plagioclase occurs in orthoclase in small dikes near the igneous contacts.

Miscellaneous Minerals. Tourmaline and sphene are common in the tactites. Of the two, sphene is the more common and forms the larger crystals. It is nearly euhedral and is more abundant in the more highly silicated rocks. Tourmaline is common in small crystals in the hornfels tactites. Apatite is not common, but is found occasionally near the igneous contacts. Tremolite and forsterite, common to many contact zones, are rare at Darwin. Their scarcity is probably the result of the relatively low magnesian content of the original sediments. The little tremolite encountered is the actinolite variety, and its occurrence is practically at the contact. A little fluorite is found in the tactites, but much of this is probably late, and principally the result of hypogene mineralization.

EVIDENCE OF ZONING AND MINERAL SEQUENCE

Zoning is not conspicuously present in the tactites at Darwin. The existence of mineral zones of metamorphism about intrusives is well known. However, the best examples of metamorphic zoning are in argillaceous rocks. Furthermore, homogeneity in bulk composition of the country rocks is necessary to establish clear cases of zoning.

At Darwin the igneous contacts generally parallel the stratification of the tactites and hence no uniformity of original bulk composition can be assumed normal to the heat source. The pure and impure limestones do not mineralogically zone with the readiness of some argillites. As a result of the irregular permeation of the country rock by igneous emanations, no uniformity of temperature gradient existed away from the contacts.

For these reasons mineral zones are only meagerly developed. However, certain tendencies can be indicated:

(1) Decrease in size of grain away from contacts and metasomatic centers.

(2) Epidote practically confined to the immediate contact.

(3) Darker colored garnet zones adjacent to some contacts, indicating introduction of iron into the lime silicates near the intrusive.

(4) Hedenbergite in place of diopside near contacts, probably indicating a similar enrichment.

Sequence of mineralization in the silicate zone at Darwin is difficult to establish, and overlapping appears to exist in most cases. Wollastonite is without much doubt the earliest mineral to form. It is clearly replaced by idocrase and garnet. Sequential relationships between

[8] Harker, A., Metamorphism: p. 94, 1932.

diopside, garnet, and idocrase do not admit of positive proof. Orthoclase appears to form more abundantly near the contacts, while oligoclase forms at a greater distance and is indicative of lower grade metamorphism and therefore formed earlier. The paragenesis of the principal silicate minerals is about as follows: wollastonite, idocrase, garnet, diopside, plagioclase, and orthoclase. If this order of formation is correct, then it may be observed that the earlier minerals are the highest in lime and that the trend is toward increased silica and alkalies. This is perhaps the trend to be expected in the metamorphism of a carbonate rock adjacent to a siliceous intrusive, and it further demonstrates the metasomatic nature of the silication process.

ALTERATION OF THE IGNEOUS ROCK

The intrusive rocks have suffered considerable yet variable alteration paralleling that in the tactites and in the ore-bodies. The alteration minerals fall into two groups. The earlier higher temperature group includes garnet, orthoclase, diopside, calcite, clinozoisite, and epidote. The second, lower temperature group includes sericite, chlorite; pyrite, quartz, kaolin, leucoxene, and possibly jarosite. It must be admitted, however, that the division between the two groups is not sharp, and proof that some of the minerals in the two groups did not develop contemporaneously is wanting. In general, garnet, diopside, calcite, and epidote are products which involve some transfer of material, particularly lime, from the sedimentaries. These minerals are common in the intrusive near the contacts. Thus, in the quartz diorite near the Thompson mine there has developed considerable calcite, epidote, and pyrite, the last mineral being clearly related to fractures. In addition, diopside, clinozoisite, chlorite, sericite, and tourmaline are present in smaller quantities.

Garnetization of the intrusive has already been mentioned and this type of alteration is very well shown in many places. In the sill-like offshoot of the stock about 200 feet above the Defiance mine, garnet is abundantly developed. In some places here nearly the entire rock may be converted to light green, granular garnet. In other places the garnet is distinctly developed along joints. Another area of intense garnetization occurs about 300 yards west of the Charistmas Gift mine on the Hahn claim where the igneous material has been almost entirely converted to medium-grained, light brown garnet.

It is a noticeable feature that orthoclase is more abundant in many of the border phases and offshoots of the intrusive. The intrusive near the Definance mine is quartz diorite, but at the immediate contact back of the blacksmith shop orthoclase makes up nearly 90 per cent of the rock. Sometimes this development of orthoclase takes the form of small dikes or veins which in places so permeate the rock as to lose identity. Where orthoclase forms much of the rock poikilitic plagioclase, diopside, epidote, or sphene are commonly present. Perhaps epidote is the most common associate of orthoclase of this occurrence. The formation of the potash feldspar is roughly correlated with orthoclasization of the limestones.

Sericitization is widespread and sometimes very intensely developed. In places near the igneous contacts the rock is composed almost entirely of quartz and sericite. Sericitization first begins in the plagio-

clase, and pseudomorphs of sericite after plagioclase are preserved in completely altered rock. In feeble alteration where only the plagioclase is attacked, orthoclase is more or less kaolinized. In the more advanced stages, sericite spreads to the potash feldspar and at the same time quartz appears to increase as though it were a by-product of the sericite. In the final stage sericite even invades the quartz.

Much leucoxene accompanies the sericitization process and most of the leucoxene is an alteration of a black metallic mineral, possibly ilmenite. Associated with the leucoxene alteration is a small quantity of jarosite. The jarosite occurs partly as veins cutting all other minerals and partly as grains intimately associated with leucoxene and sericite alteration in areas clouded with kaolin and containing minute grains of sphene. The occurrence of jarosite intimately associated with leucoxene and sericite may indicate that the assemblage is of hydrothermal origin. Sericitization probably represents a lower temperature, hydrothermal continuation of orthoclasization. This process of forming orthoclase, along with the development of garnet, tourmaline, sphene, calcite, diopside, and epidote is best correlated with the bulk of silication of the limestones. On the other hand, sericitization and accompanying products are more nearly to be correlated with later hydrothermal processes and the metallization epoch.

Pyrite is extensively developed in the igneous rocks and for the most part is of late hydrothermal origin contemporaneous with metallization.

HYPOGENE ORE AND GANGUE MINERALIZATION

The mineralization which gave rise to the silver-lead deposits at Darwin is sharply set off from the silication process mentioned above. The silication of the limestones is conceived as having taken place during the emplacement of the stock, whereas the ore and gangue mineralization occurred after the formation of the tactite zone in subsequent fractures and other structural loci. Quantitatively, the major metalliferous deposition occurred within the tactites. This post-consolidation mineralization may be discussed in two groups: gangue and ore mineralization.

GANGUE MINERALIZATION

The gangue mineralization consists chiefly of calcite, pyrite, jasper, and fluorite. In addition garnet, orthoclase, quartz, hematite, siderite, and barite are present in lesser quantities. Garnet, orthoclase, quartz, and pyrite are deposited in the above order, replacing the quartz diorite walls of the Lane vein near the igneous contact in Lane canyon. Again in the Wonder mine 300-400 feet from the contact a similar assemblage is to be found replacing tactite walls. Here coarse calcite and fluorite are intergrown and directly associated with the ore minerals. However, the occurrence of garnet and orthoclase as post-fissuring gangue minerals is quantitatively of minor importance. In the majority of deposits, calcite, fluorite, jasper, kaolin, or pyrite make up the early-formed gangue minerals. Spongy and earthy iron oxides, derived from oxidation of the jasper and pyrite, are very closely associated with galena.

A small quantity of scheelite occurs in coarse calcite with pyrite and chalcopyrite on the Bruce claim in Lane canyon where ore carrying as much as two per cent tungsten and traces of molybdenum are reported.

There is a general decrease in the grain size and abundance of certain of the gangue minerals with distance from the stock. Extremely coarse calcite in cleavable masses 18 inches on a side characterizes such deposits as the Defiance, Custer, and Wonder, all of which are at or near the intrusive. Farther from the contact calcite is finer textured and somewhat less common. Rose, green, or white varieties of fluorite, common associates of galena in deposits near the igneous contacts, are much less common or are absent at a distance. Pyrite or pseudomorphs of limonite after pyrite, in sizeable pyritohedrons and cubes are abundant in deposits near the stock. In contrast, the pyrite in deposits at some distance from the intrusive is granular, less common, or absent. Likewise, the early garnet-orthoclase mineralization is relatively more common in proximity to or within the intrusive. Jasper, on the other hand, is universally present, but relatively more abundant as a gangue mineral in those deposits situated some distance from the stock. (See Fig. 20.)

ORE MINERALIZATION

Galena and its alteration products constitute the principal ore minerals of the district. Galena is found in association with all of the gangue minerals mentioned above and in a few places, as at Essex mine, it has impregnated and replaced the silicate minerals of the tactite. (Fig. 21.) Occasionally it is found replacing igneous rock along fractures. Notwithstanding its varied associations, its dominant occurrence is in lenticular or tabular deposits with calcite, fluorite, pyrite, or jasper, or the oxidation products therefrom. Spalerite and, to a lesser extent, chalcopyrite, occur with galena in many places.

Megascopic Features of the Ore

The primary ore is predominantly argentiferous galena and it occurs in bunches, lenses, or tabular veins distributed through the gangue of the deposits. The galena varies in texture from fine-grained or steel galena to coarser material in which individual interlocking crystals may attain one or two inches in diameter. The most common variety is medium-grained and it is often characterized by a banded texture in which curved cleavage faces are the rule rather than the exception. (Fig. 18.) Nearly all of the galena contains occasional visible inclusions of chalcopyrite. In one or two of the deposits of the district chalcopyrite and its oxidation products make up the entire ore mineralization. However, as a rule the quantity of chalcopyrite seen in the galena is small. Sphalerite and pyrite are associated in greatest abundance with galena. Sphalerite is very common in parts of the Defiance, Thompson, and Intermediate orebodies. Some of the masses of sphalerite in the Thompson mine are very coarsely crystalline with individual cleavage pieces two or three inches in diameter. Masses of argentite are reported from some of the deposits, but none was found during this investigation. Likewise thin sheets of native silver are reported from several of

the properties, but these were probably secondary products resulting from local reduction of silver solutions or silver minerals.

The sulphides are later than the primary gangue minerals. In polished hand specimens from the Rip Van Winkle and the Essex ores small veinlets of pyrite and galena cutting quartz, fluorite, and calcite can be seen.

In the north end of the Darwin Hills about one mile northwest of the stock there is an antimony prospect containing irregular bunches and radiating groups of stibnite. Blades three to four inches in length replace a matrix of arenaceous limstone along bedding planes and small cross fractures. The stibnite has been largely oxidized to cervantite. Numerous cavities contain pseudomorphs of cervantite after stibnite. The isolated nature of this deposit makes it impracticable to relate it to the lead mineralization about the stock.

Microscopic Features of the Ore

Polished specimens were studied of all the varieties of primary ores that could be obtained in the district. The mineralogy was found to be rather simple and the paragenesis in all of the ores examined, whether from near the intrusive or at a distance, was essentially similar. Galena is the latest primary mineral to form. It replaces all other minerals including sulphides and nonmetallic gangue minerals alike. (See Figs. 21 and 22.) It commonly contains numerous inclusions of pyrite, chalcopyrite, sphalerite, luzonite, and tennantite. All of these inclusions are clearly residual to the galena replacement. They may occur as individual inclusions, or more often, as irregular intergrowths of the two. The sulpharsenides of copper were considered the most likely to carry silver values in the galena, but a microchemical test gave no test for silver.

A noticeable feature of polished galena from the Christmas Gift mine and from the Promontory mine is that inclusions of luzonite and tennantite are more numerous than in the galena from the Defiance-Independence group of mines. The Defiance and Independence ores have averaged about one ounce of silver to each one per cent of lead, whereas ores from the Lucky Jim, Christmas Gift, and Promontory have averaged about two or three ounces to each one per cent. In other words, the silver values have been higher from the deposits near the ends of the stock which were in association with the more basic rocks. Since it is common for the sulpharsenides of copper to be the source of silver in galena ore, it may be that the increase in silver values is proportional to their abundance.

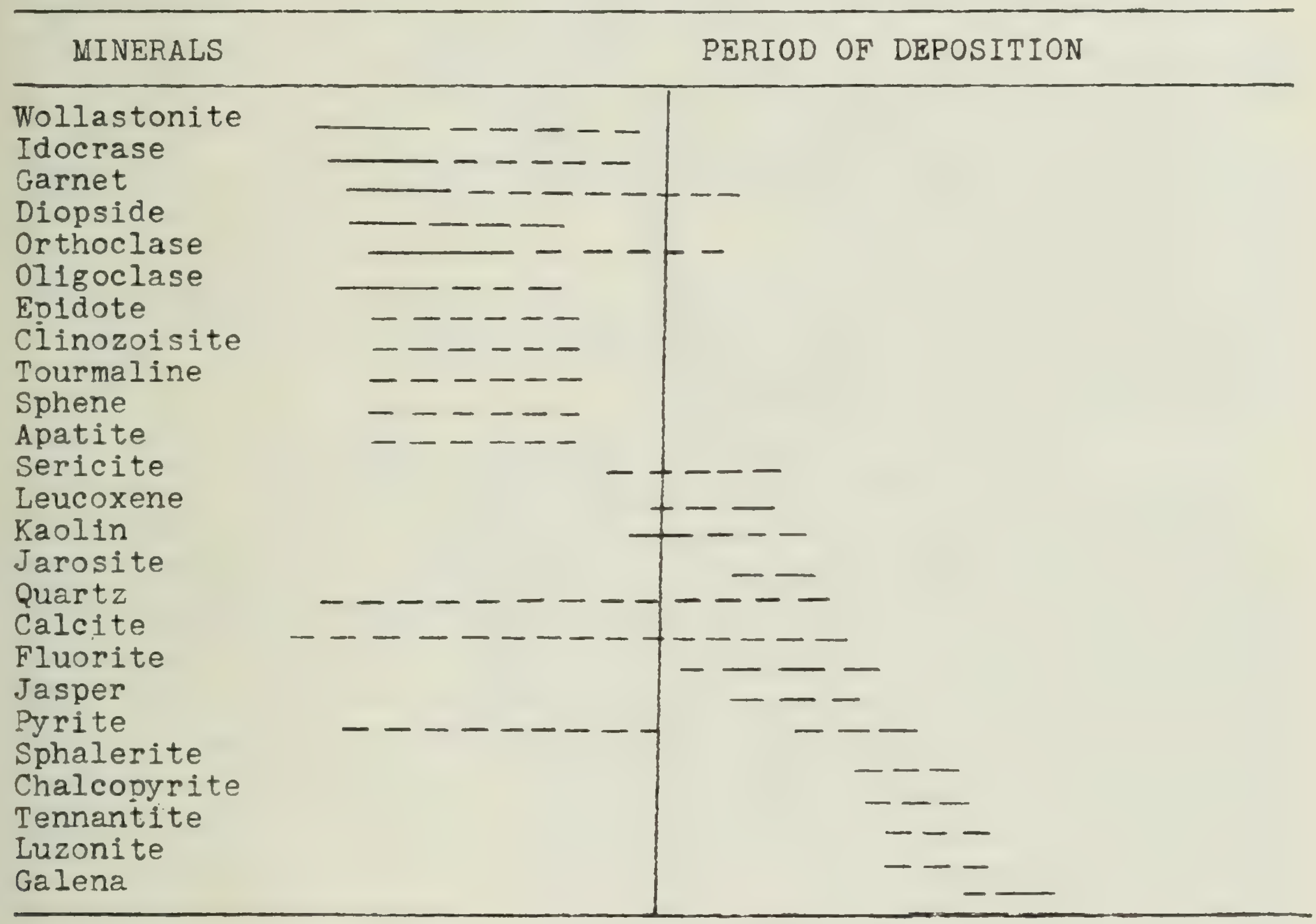
The microscopic evidence indicates a sequence of deposition in the following order: pyrite, sphalerite, chalcopyrite, tennantite-luzonite, galena. The accompanying photomicrographs show most of these relationships. Sphalerite commonly contains small spines of chalcopyrite more or less uniformly scattered through it in a manner suggesting an origin by unmixing.

SUMMARY OF THE MINERAL PARAGENESIS

Wollastonite and idocrase, the earliest minerals formed, were rich in lime. Minerals formed later were increasingly enriched in silica. Silica was introduced into the limestones at an early stage and con-

tinued to be introduced until the deposition of the sulphides. The early high-temperature introductions of silica produced silication. The final consolidation of the igneous rock was followed by a period of fracturing. However, silica continued to be supplied, but under lower temperatures silication gave way to *silification* in the intrusive and in the epigenetic deposits, first as a quartz and later as jasper. In a similar manner, but to a lesser extent, iron was added over a long period, beginning during the silication with the formation of garnet zones adjacent to some contacts, and continued under hydrothermal conditions in the form of jasper and pyrite.

A generalized picture of the paragenetical relationships is given in the table below.



SUPERGENE ALTERATION

At Darwin, as might be expected from the aridity of the climate, oxidation and supergene alteration have extended to great depths. The present depth of mining operations, which is only 1000 feet in the Lucky Jim mine, has not penetrated below the zone of oxidation. Oxidation has been very thorough as revealed by the abundance of porous, gossanized gangue in nearly all of the deposits. The gossanized material has been almost entirely derived from pyrite, jasper, and hematite. A small amount has been derived from the decomposition of iron-bearing sphalerite.

Cerusite greatly predominates among the oxidized lead minerals. To date a larger portion of the lead production has been obtained from cerusite than from galena, thus indicating the completeness of oxidation. Anglesite is not common except in the thin coronas immediately surrounding the galena masses. Plumbojarosite is reported from some of the deposits, and its origin was probably supergene. In the more

highly oxidized near-surface ores it is probable that the oxides of lead formed in small quantities, although none was observed. Native sulphur is rather common associated with some of the sulphide oxidation products. Considerable horn silver was probably present in the surface ores, although none was found during the present work. It was probably so intermixed with either the iron oxides or oxidized lead ores that it was seldom seen. In any event its presence seems substantiated by the fact that the surface ores, spoken of as the 'cream' of the deposits, were often very high in silver. Moreover, some of the early mining reports describe the ore as consisting in part of horn silver.[13] This is, of course, in keeping with the known facts regarding concentration of silver values near the surface during oxidation of the primary ore.

The thin sheets of native silver reported to have been found in the Thompson and Lucky Jim mines probably resulted from alteration and local reduction of the primary argentiferous lead ores.

A little smithsonite, in keeping with the quantity of sphalerite present, is also found. Likewise the small quantities of chalcopyrite and sulpharsenides of copper found in the primary ores have contributed to the formation of chrysocolla and melaconite in many of the oxidized ores. An almost insignificant amount of secondary sulphide enrichment is seen in some of the primary sulphides in the form of covellite and, more rarely, chalcocite.

STRUCTURAL CONTROL OF ORE DEPOSITION

From the position and nature of the deposits about the Darwin stock it is evident that structure was the dominant controlling factor in their location. However, to some extent the composition of the enclosing wall rocks has had a modifying influence on the local accumulation of ore. There are three types of structural controls: (1) intrusive contacts, (2) bedding planes, and (3) transverse fissures. A single deposit may be localized by two controls, or pass from one into another. Commercial deposits of the first type are found only along the west contact of the stock.

DEPOSITS ALONG INTRUSIVE CONTACTS

The deposits formed at igneous contacts are the largest in the district. Along straight stretches of the contact, deposits of this type may be long, narrow, tabular bodies resembling the fissure deposits. In general, however, the contact deposits are lenticular in plan and although shorter in outcrop length than the cross fissure deposits, they are usually thicker. They vary in length along the contact from a few feet to two or three hundred feet. Likewise the width may vary from less than one foot to 20 or 30 feet. They extend downward irregularly along the igenous surfaces.

Irregular protuberances of the intrusive into the country rock often show more pronounced mineralization. Local warping of the adjacent strata or flattening of the contact surface also appear to be instrumental in impounding of ore. Such features may have been effective along the contact between the Defiance and Independence mines, where the intrusive has forced its way into a small anticlinal

[13] Inyo County: Calif. Min. Bur., 12th Ann. Rpt., p. 24, 1893.

fold paralleling the stock and thus flattening the contact surface to some extent. Underground development of these deposits has, however, not been sufficient to permit a full analysis of their localization.

The Defiance and Independence orebodies are the outstanding examples of deposits along igneous contacts; but smaller deposits of a similar nature are to be found at several points north and south of these. On the west side of the stock the contact roughly parallels the stratification of the tactites, forming an effective structural trap along the surface for deposition of ore. In contrast the east side of the stock bears cross-cutting relationships to the stratification. Here the contact surface formed practically no effective trap for the ore solutions, which probably passed outward along the bedding planes and fractures. As a result of this structural condition, there are no mines of any consequence located on the east contact of the stock. The only deposits at the contacts which have produced are those located on the west side of the stock. The type of ore mineralization together with the associated gangue is similar or identical to that of many of the bedding-plane and fissure deposits.

BEDDING-PLANE DEPOSITS

Numerous deposits have been formed along bedding planes, particularly along the east side of the stock where ore solutions found easier avenues of escape from the contact both by reason of more numerous cross fractures and by bedding planes which dip steeply into the contact. The outstanding deposits of this type are the Custer, Jackass, Fernando, and Keystone on the east side, and the upper Defiance and Promontory on the west side. Many of the deposits are layered or sheeted as a result of replacement of several thin beds. Others, such as the Fernando and Keystone, have formed at the intersection of fissures with favorable stratification planes, and as a result have a chimney-like shape. At the Keystone the deposit is dominantly on the fissure. In some instances where the igneous contact cuts slightly across the stratification, contact deposits continue or branch into bedding-plane deposits. The Custer and upper Defiance bedding-plane deposits are only 20 or 30 feet from the igneous contact. Others such as the Promontory and the Keystone deposits, are 1000 to 1500 feet from the contact.

TRANSVERSE FISSURE DEPOSITS

Deposits of this type are the most numerous in the district; although of considerable importance it is doubtful whether they will outproduce the deposits formed at the igenous contacts. The fissure deposits are most important and numerous on fractures trending northeasterly, nearly at right angles to the elongate direction of the stock. Many of these are confined to the tactite or extend only a short distance into the intrusive, where they are taken up by multiple adjustments along joint planes. Others, such as the Standard or Lane veins, cut entirely across, or extend well into the stock. Fissures of this type are mostly vertical, or dip steeply to the north.

Fissure veins of this type are intersected by a northwesterly belt of mineralized fissures which lie north and east of Ophir Mountain. On these fissures much shearing is evident, accompanied by greater

width of mineralization, in the form of jaspar, calcite, and barite. Metallization, however, is sporadic and the ground of these veins is as yet unproven.

The Christmas Gift, Lucky Jim, Lane, and Columbia mines are the outstanding producers of fissure veins. The width of the fissure veins averages two to six feet; locally, stopes 25 to 30 feet in width have been mined. Ore and gangue mineralization in the transverse fissure veins is in many places the same as in the deposits along the igneous contacts. Those veins which extend from the tactite into the igneous rock show by contrast the influence of the wall rock on deposition. In the intrusive the veins become restricted and ore and gangue scarce and sporadic.

In the following table the mines of the district are arranged according to their distance from the stock, and the dominant structural control and mineralization are indicated. Mines on deposits along contacts are restricted to the west side of the stock.

	Mines	Structural control			Feet from Ig. contact	Characteristic gangue minerals				
		Contact	B. plane	Fissure		Pyrite	Jasper	Quartz	Calcite	Fluorite
West side of stock	Independence	x			0	x	x		x	
	Essex	x			0	x				x
	Defiance	x	x		0	x	x	x	x	x
	Bernon		x		50	x	x			
	Thompson			x	100	x	x	x	x	
	Lucky Jim	x		x	200	x	x	x		
	Bell Union		x		200	x	x			
	Rip Van Winkle			x	500	x	x	x	x	x
	Promontory		x		1,000	x	x	x		
	Fairbanks			x	1,500	x	x	x		
East side of stock	Standard Ext.			x	50	x	x	x	x	x
	Custer		x		50	x	x	x	x	x
	Christmas Gift			x	300	x	x			
	Standard			x	400	x	x		x	x
	Silver Spoon			x	500	x	x	x		
	Wonder		x		1,000	x	x	x	x	x
	Fernando			x	1,000	x	x	x		
	Jackass		x		1,200	x	x			
	Keystone		x		1,500	x	x			
	Santa Ana			x	2,000	x	x			
	Lane			x	2,200	x	x			
	Columbia			x	3,000		x			

ORIGIN AND CLASSIFICATION OF THE DEPOSITS

The position of the Darwin silver-lead deposits is clearly controlled by the form and extent of the stock. The stock was guided in its emplacement by the structure of the strata of Pennsylvanian age.

Advancing with and ahead of the igneous material were emanations which carried great quantities of silica and lesser quantities of other metals, chief among which was iron. Heat energy which promoted recrystallization and metasomatism was carried largely by the magmatic emanations. The effect of conducted or diffused heat was distinctly subordinate to that of conveyed heat. The heat and chemical action of the pervading emanations caused great quantities of carbon dioxide to be liberated and driven off. Simultaneously with the liberation of carbon dioxide, silica and other metals were added, thus preventing any appreciable volume reduction and consequent obliteration of bedding structure.

The stock was intruded into rocks already considerably silicated and thoroughly heated. This is evidenced by the absence of chilling on the margins of the stock or the small dikes in the tactite, and by the lack of any detailed relationship of silicate aureoles to these offshoots of the stock. That a lesser amount of silicate replacement accompanied or followed the intrusion is shown by garnet zones marginal to the stock or replacing it.

The development of the tactite aureole and the final consolidation of the intrusive was followed by a period of fracturing. Many of the fissures of the resulting fracture system are rather persistent and continue through the stock and the wide silicate aureole alike. Displacements, which offset the igneous contacts occurred along some of the fissures prior to their mineralization.

All of the hypogene lead mineralization and deposition of ore in general occurred after this period of major fracturing. Some dislocations actually post-date the period of metallization and have brecciated or offset the orebodies. This period of fracturing distinctly separates the period of silication, in which the tactites developed, from the period of metallization in which all of the ore of the district was formed. The silication developed under high temperatures in advance of and attendant upon the intrusion. The ore deposition developed under low temperature, hydrothermal conditions.

Knopf thought the deposits indicated a "sequence in time" with decreasing temperature as "The fissure veins are regarded as representing the low temperature end of a genetically related series of deposits formed at progressively decreasing temperatures," Knopf, (p. 9, 1914) and "the galena ore of the Darwin district began to be deposited under pyrometasomatic conditions, but its maximum deposition occurred at a lower temperature," Knopf, (p. 533, 1933) and further, in comparison, "the Coeur d'Alene district represents a sequence in time." Knopf, (p. 10, 1914).

A temperature gradient existed away from the intrusive, but this only effected a crude zoning of grain size and to a lesser extent of mineralization. If decreasing temperature determined the place of deposition it is more likely that deposition would first take place at a distance from the intrusive in fissures and bedding planes, and later, as the temperature fell, at the contact; but there is no indication of long continued deposition of ore with falling temperatures, and temperature was apparently not the controlling factor in the relative time or position of the deposits. The simplicity of the ore and paragenesis does not warrant a long continued deposition, and there is little or no

overlapping of mineralization. Instead, the controlling factors were (1) a deep-seated supply of differentiated metals and their associated gangue substances following consolidation of the intrusive and fracturing of the rocks, and (2) the effective opening of fissures, stratification, and contacts to the ore-bearing solutions. The ore deposition was all accomplished during a single short period under nearly constant temperature conditions following fracturing. The only division or classification to be made is one of structural control as already described.

Knopf (1933) has chosen Darwin as an example of a pyrometasomatic lead deposit. As evidence of a connection between pyrometasomatic deposits and fissure veins Knopf (1914) cited the Independence orebody as an example of the contact pyrometasomatic type of deposit, and the Defiance orebody as intermediate or transitional link between the contact type and the fissure veins of the district. This conclusion was based on finding apatite in orthoclase associated with primary sulphides at the Defiance mine and andradite garnet with galena at the Independence.

The deposits occur near each other along the same intrusive contact, and on the whole the mineralization is much the same except that in the Defiance orebody exceedingly coarse calcite is more abundant. Galena and other sulphides have impregnated the tactite walls to some extent in both deposits, but such close association does not necessarily indicate that the sulphides formed under the high temperature and pressure conditions that the garnet or orthoclase did. In fact, there is little in either deposit which can be used to set them apart, or to set either apart genetically from the fissure veins, especially as regards time, sequence, and substances available through ore-forming solutions. In a sense, it is better to view them all as fissure deposits. During metalization some fissures were effectively opened along contacts and bedding planes, and others along transverse fractures.

The deposits along contacts and in fissures are similar mineralogically and structurally. There is little necessity for demonstrating a transition, for they are genetically identical. The fissures have the regularity of strike and dip of mesothermal deposits. The walls are smooth and well-defined. Furthermore, the regularity and sharp definition of the contact deposits compares with that of the fissures. The mineralization directly associated with the deposits is not on the whole of the pryometasomatic type. Jasper, which is one of the most common gangue minerals in the deposits, is indicative of formation at temperatures attributed to mesothermal deposits. Both fluorite and barite are common minerals in low temperature deposits. During the existence of the pyrometasomatic environment about the stock, the characteristic minerals developed were garnet, orthoclase, quartz, specularite, and scheelite; but this mineralization was not great. The lead mineralization developed at a later stage in association with fluorite, calcite, barite, and jasper in a mesothermal environment. There is no pyrometasomatic galena. Both fluorite and barite are common in mesothermal or epithermal deposits.[14] Initial pressures and temperatures may have been such that a hypothermal stage was not represented.

[14] Lindgren, W., Differentiation and ore deposition: Ore Deposits of the Western States, p. 154, 1933.

Umpleby,[15] from findings at Mackay, Idaho, and from study of numerous other districts, has formulated the generalization that ore about intrusive bodies tends to form on the limestone side of garnet zones. It was his observation that where ore came directly against the igneous contact practically no barren lime silicate would extend beyond the ore. Darwin appears to be an exception to this, for the silicate rocks in most cases extend far out beyond orebodies at contacts. Of the two contacts, silicate-igneous and silicate-limestone, the latter would in all probability be more easily penetrated by ore solutions. Where the silicate zone is wide, stratification well preserved, and fissures common, the rule formulated by Umpleby would be less applicable because of the preponderance of structural control.

EPOCH OF MINERALIZATION

The epoch of metallization and hence most of the ore mineralization took place after the intrusion of the stock. The silication of the limestones occurred during the emplacement of the igneous rock. Fracturing of both the tactite and the consolidated intrusion set the stage for the ore deposition. There is evidence that displacements continued during the ore deposition of the type termed by Hulin [16] as intermineralization fault movements. And as pointed out by Hulin these movements facilitate the accumulation of ore shoots. The ore-forming epoch which followed shortly the intrusion of the stock is probably best dated as late Mesozoic.

MINING HISTORY AND PRODUCTION

During the early seventies the rich ores of Panamint City and the Ballarat district were shipped by pack train through Shepherd Canyon in the Argus Range and thence by a route following springs along the east front of the Coso Mountains to Owens Valley. A Mexican searching for a mule lost from the packers' camp at Old Coso or Coso Springs is reported to have discovered an outcrop of ore in the Darwin Hills. The initial discovery is reported to have been made in 1874. The lode which was found was evidently rich enough to have attracted considerable attention, for during the year many other deposits in the district were located. Most of the important mines were started during the years 1874 and 1875. A good-sized town soon sprang up and was named after Dr. Darwin French who had lead a party of 15 men through Darwin Canyon in 1860 in search of the mythical Gunsight silver lode in Death Valley.

During the early boom days of the seventies there were eight blocks of buildings along the main street and six in the other direction. The population is said to have then exceeded that of Los Angeles. In the early days, Darwin was twice burned to the ground by wind-whipped fires, which probably accounts for the present lack of indications of the former size or character of the town.

From 1875 to 1877 three smelters were built near Darwin. The Cuervo had a capacity of 20 tons per day; the Defiance 60 tons; and the

[15] Univ. of Calif., Publ. Geol., vol. 10, p. 26, 1916.

[16] Hulin, C. D., Structural control of ore deposition: Econ. Geol., vol. 24, pp. 15-49, 1929.

New Coso 100 tons. The lead well of the New Coso smelter was started from lead obtained from Cerro Gordo. Iron oxides used at the smelter were obtained from iron mines on Centennial Flats in the Coso Mountains. Charcoal was obtained from timber burned in the Coso Mountains. It is also interesting to note that many of the eight by eight stulls still present in some of the older workings were hand-hewn from timber obtained in the Coso Mountains.

During the early days of mining all freight had to be hauled by team from Los Angeles, and consequently costs were very high. Only the richest ores were sent to the smelter; according to De Groot,[17] about one foot broken out of the ledge averaging twelve feet in width constituted ore at the Defiance mine. About four-fifths by bulk and about one-half of the value went into the dumps. Because of the excessive transportation costs and the exhaustion of these more easily mined rich ores, the smelters were shut down within a few years, prior to the completion of the narrow-gauge railroad to Keeler in 1883. After shutdown of the smelters, jigging of the ores came into practice and concentrates obtained from newly mined ore and from the dumps were shipped to smelters at Selby or Salt Lake.

During the eighties and nineties mining and production were sporadic and at times practically dormant due to poor transportation, lack of modern mining facilities, and some litigation. Some leasing and shipping were carried on from 1900 to 1910, but only small activity was reported by Knopf in 1914. In 1915 the Darwin Development Company consolidated the Lucky Jim, Promontory, Lane, and Columbia mines and began the construction of a mill on the Lane property. This company soon gave way to the Darwin Lead-Silver Development Corporation, and finally, in 1917 the Darwin Silver Company consolidated the above properties with the Defiance and Independence mines purchased from the Reddy Estate. Modern equipment, roads, and camps were constructed with the view of mining on a large scale, and although considerable ore was blocked out and nearly a half-million in richer ore was shipped, real mining awaited camp building and surface developments. The camp was financed by E. W. Wagner and development was managed by A. G. Kirby in 1921. During the height of the development Wagner committed suicide because of reverses in speculation growing out of the grain crash in 1920. Kirby leased the properties from the Wagner Estate during the period of 1922 to 1924 and produced some ore, but on account of estate complications was forced to quit.

The Lucky Jim mine, one of the big producers of the district, was mined extensively in the early days. According to J. A. McKenzie, who owned the mine at the time Goodyear reported on the district in 1888, the mine at that time produced about \$1,250,000 or \$1,500,000, but probably more money had been spent on the mine than had been taken out. At the time of Goodyear's visit the mine had been opened 300 feet by vertical shaft and 180 feet below the bottom level by an inclined winze. Although some mining had been done during the intervening time, no greater depth had been attained at the time of Knopf's work in 1913. The Darwin Development Company working the mine in 1915 had deepened it to 600 feet. The Lucky Jim camp above the

[17] Calif. Min. Bur., Tenth Ann. Rpt., p. 211, 1890.

mine was built about this time, and the Lucky Jim continued to be deepened and mined until about 1926 when a depth of about 1000 feet was reached. The Defiance, Independence, and Lane mines were also worked to a considerable extent during the period from the World War to about 1927. The larger ore body in the Independence mine was opened up and worked during this period.

With the straightening out of the Wagner Estate affairs, the American Metals Company under C. H. Lord of Chicago leased the properties and operations again began. Considerable ore was concentrated and shipped during the period 1925 to 1927. But by 1927 the lead industry was becoming depressed and the camp was again shut down. In 1928 an open switch in the Lucky Jim mine caused a fire which burned out much of the shaft and mine timbering. As a consequence this mine, perhaps the largest in the district, is inaccessible.

In 1936 with the return of more favorable mining conditions and better prices for lead and silver, the Darwin properties were again opened up in preparation for mining. The Wagner Estate properties were reorganized as the Darwin Lead Company. By the end of 1936 the Lane mill had been rebuilt to 200-ton capacity and early in 1937 the Thompson tunnel was cleaned out in preparation for working the Independence orebody at a lower level. A. A. Rubel in 1936 purchased the Keystone properties in the south end of the hills and constructed a modern camp in preparation for extensive development under the name of Keystone Darwin Limited.

It is evident from the history of the camp that there have been two contrasting periods of production. The first, in the early seventies, was halted because of depletion of the rich surface ores, and because of lack of modern methods of mining and milling and transportation applied to low-grade ores. The second began with the World War impetus to mining during which consolidation of properties and large-scale operations were effected. This later period faltered during the unprecedented depression, but should now swing into full stride again. With modern methods of mining, ore treatment, and transportation the Darwin district should prove its position as a silver-lead producer.

The following table of production from the more important mines in the district is based partly upon figures and estimates made by previous writers and partly upon estimates from information gained during the present survey:

Mine	Estimated Production
Lucky Jim	$2,000,000
Defiance	1,500,000
Christmas Gift	550,000
Independence	500,000
Lane	300,000
Custer	250,000
Promontory	200,000
Thompson	100,000
Columbia	100,000
All others	300,000
Total	$5,800,000

MINES

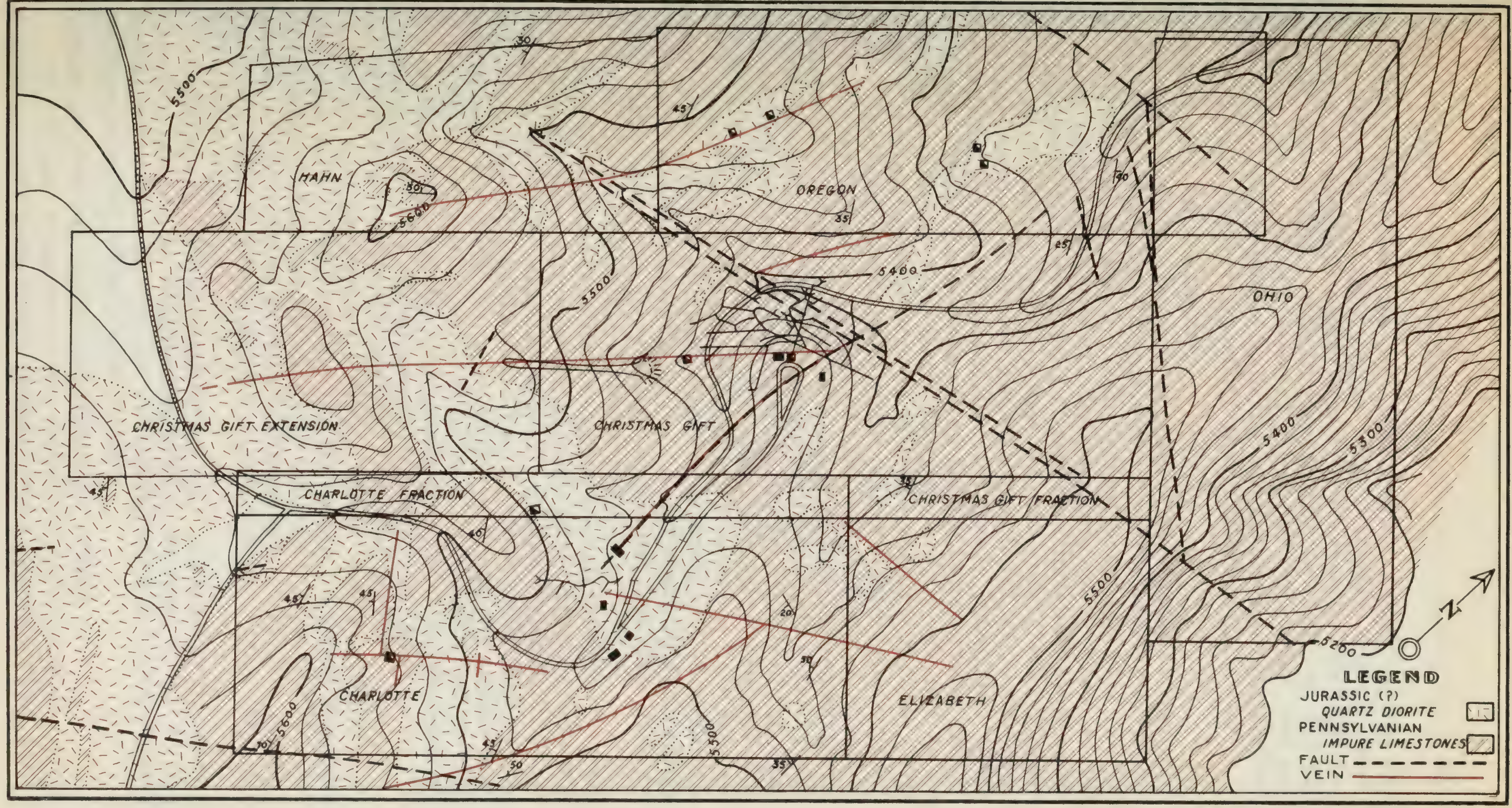
MINES IN THE NORTH END OF THE DARWIN HILLS

Fairbanks Mine—The Fairbanks mine is situated about three miles north of Darwin and about 1700 feet northwest of the Lucky Jim mine at an altitude of 5500 feet. The orebody occurs in a small chimney-like vertical vein which strikes northeasterly within the zone of the Darwin tear fault. The wall rock, composed of impure limestones, strikes S. 38° W., a trend considerably at variance with the regional trend due to the drag effect of the large fault. Although the exact relation of the ore-vein to the tear fault could not be determined, the vein is probably subsidiary to the major fault, the ore originating from solutions which rose along the fault. The vein matter consists of galena and cerusite in a gangue of quartz, fluorite, calcite, and iron oxides, the latter probably derived as gossan-like material from jasper and pyrite in the original vein. Some galena occurs in the outcrop.

Lucky Jim Mine—The Lucky Jim mine is situated about three miles north of Darwin at an elevation of 5000 feet. It is located on a rather persistent vein which strikes N. 50° E. and dips 80° NW. About 500-600 feet southwest of the shaft the vein is broken by two faults which strike northwest. The dislocation on each of these faults is about 50 feet, and, as is the rule in the district, the north side has moved westward. The principal ore shoot is inclined to the southwest about 30° and has been worked downward in a series of tunnels and winzes to about 1000 feet. The vein averages four to six feet in width, but in places is nearly 20 feet. To the northeast the vein cut less metamorphosed limestones that have been throne into series of small folds. The ore consists of bunches of galena and cerusite occurring in an oxidized jasper gangue. Only small quantities of calcite, pyrite, and fluorite are found. The ore averaged 1-1½ ounces of silver to each one per cent of lead. The lead percentage of the ore mined varied with the stope, but is reported to have been 8-10 per cent. The surface cuts are reported to have been much higher in silver than at depth.

Christmas Gift Mine—The Christmas Gift mine (Fig. 25) is located about 2000 feet southeast of the Lucky Jim mine on a vein which strikes N. 40° E., and dips about 80° NW. The rock in the vicinity of the mine is stratified tactite which has been pierced by many small dikes and irregular offshoots, of the Darwin stock as shown in Plate V. Although the tactites are considerably disturbed by the intrusions, in general they strike N. 30° W. and dip 30-40° W.

As can be seen on the geologic map of the Christmas Gift claim group, an intricate system of fissures and faults has been superimposed upon the multiplicity of small intrusions into the tactites. Among the fissures are several parallel to the Christmas Gift vein; these in general have been most highly mineralized. The Christmas Gift vein is cut off by a compound fault about 200 feet northeast of the shaft. This fault strikes N. 70° E. and dips 75° S. The north side of this fault has shifted west and in the vicinity of the mine the displacement is about 450 feet. The apparent displacement dies out very rapidly to the east and west. The ore shoot mined in the Christmas Gift mine pitches steeply southwest and is about 300 feet in stope length. The mine is



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GEOLOGIC MAP OF THE CHRISTMAS GIFT CLAIM GROUP

BY VINCENT C. KELLEY 1936.

SCALE
0 100 200 400 FT.
CONTOUR INTERVAL 20'

opened by a shaft down the dip of the vein to a depth of 400 feet with drifts along the fault or the vein to intersect the ore shoot. Because of the trough structures formed by the planes of the fault and the vein, the ore shoot ends sharply against the fault on the 250 level. The ore consists of bunches of galena and considerable lead carbonate. The ore is imbedded in earthy iron oxides apparently derived from pyrite and jasper, remnants of which still occur in the vein.

MINES OF THE ROUNA GROUP

In this group are included the mines and prospects located in the canyon north of Lane Canyon through which the highway passes. All of the deposits are in fissure veins along the east side of the stock, directly opposite the Independence mine. Most of the work has been done on two large and persistent northwesterly trending fissures which converge from the west and unite near the development camp in the canyon. In the twenties both branches of the fissure system were explored by tunnels several hundred feet in length, but no ore was found. These fissure veins are among the largest in the district, attaining a width of 40-50 feet. The walls are very definite as the result of irregular impregnation of sheared zones on either side of the fissure. Jasper and calcite make up the bulk of the veins, but considerable barite can be found in places. In the tunnels and open cuts small quantities of chalcopyrite, sphalerite, and pyrite are occasionally found. To date, however, practically no production has come from these northwest-trending veins, and it is quite probable that, in spite of the extensive gangue mineralization of jasper and calcite, they were not effectively opened to sulphide mineralization. These veins have been followed by narrow dikes of basalt and aplite in the vicinity of the tunnels. The basaltic material is not like any of the dike rocks definitely related to the major stock, and there is some suggestion that these dikes are later than the mineralization of the fissures.

Several northeast-trending veins have been exploited in this group and, although these are narrower and less persistent, they show mineralization of a more encouraging type. Of these veins the Standard has been most developed, and from it, considerable lead ore has been mined. It outcrops on the south side of the canyon and lies south of the above-mentioned fissures. The vein is two to six feet in width and contains coarse calcite, much gossan iron oxide, and the favorable ore indicator, fluorite. Large masses of galena were found in the vein in addition to a considerable amount of oxidized lead ore.

In the twenties, during the driving of the tunnels on the large fissure veins, a small camp was built in the canyon. A recent cloudburst destroyed or washed away much of the equipment. That which is left consists of two portable pneumatic compressors of 130-foot capacity, an Ingersoll-Rand drill sharpener, blacksmith shop, mine cats, rails, and air and water pipe.

Considerable electrical exploration work was done by the Radiore Company prior to the development work in an effort to find the best indications of ore. Most of the indications obtained by the electrical work are, however, evident on the surface.

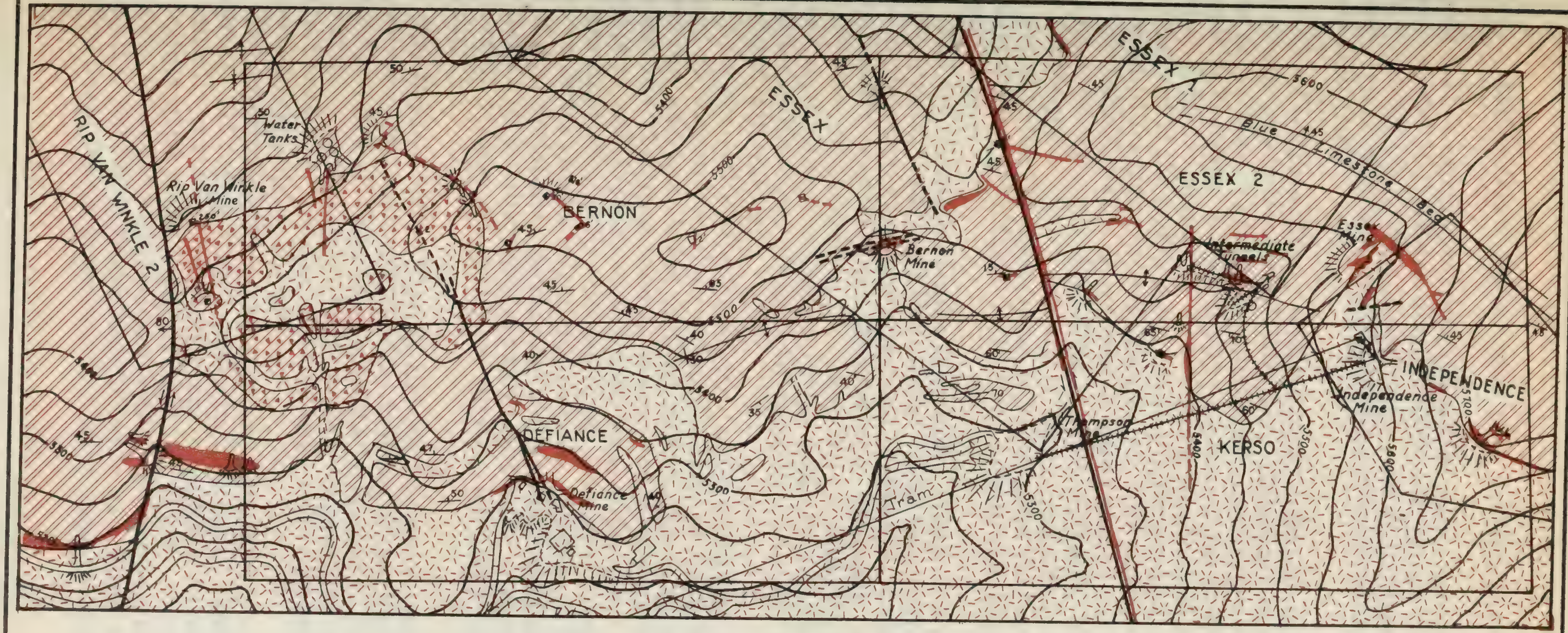
MINES OF THE DEFIANCE-INDEPENDENCE GROUP

The mines of this group are lcoated along the east side of the prominent ridge back of the Darwin Lead Company's camp, within

one mile of Darwin. The mines are centered about two large tabular orebodies at or near the west contact of the stock. The southern orebody is worked by the Defiance mine and the northern orebody is opened by the combined workings of the Independence, Essex, and Thompson mines.

The *Independence Mine* (Figs. 27 and 28) is located one and a half miles north of Darwin at an elevation of 5600 feet near the top of the prominent ridge extending southeasterly from Ophir Mountain. The orebody is poorly exposed at the surface. The initial discovery and entrance to the orebody was made by an inclined shaft located on the crest of the ridge at an elevation of 5700 feet. At this point, along the contact, a tabular vein about 20 feet in width outcrops. Northward from this entrance the outcrop of the vein can be traced several hundred feet before it pinches out. South of the ridge crest the outcrop of the vein pinches out in about 50 feet. Two smaller parallel veins lie in the beds a few feet above the vein at the contact. Entrance was later made to the orebody by a tunnel on the south side of the ridge through a lobe of quartz diorite near the contact. The orebody within the ridge above the elevation of the tunnel is enormous and stopes in this region are the largest in the district. At the tunnel level the orebody is 100 to 150 feet in width and the stope length is about 200 feet. The footwall of the orebody is in most places quartz diorite although sometimes a narrow layer of tactite intervenes. The hanging wall is limestone and tactite. The bulk of the orebody consists of a porous, highly weathered, gossan-like material which contains many pseudomorphs of limonite after pyrite. Considerable kaolin, calcite, siderite, quartz, and jasper occur throughout the gossanized vein material, much of which is mined as high-grade milling ore. Small unmined remnants of galena and cerusite which undoubtedly occurred in larger masses can be found scattered through the gossanized walls of the stopes. The ore stoped from above the tunnel level probably extends downward along the contact for a considerable distance. The unmined ore in this orebody probably constitutes one of the largest reserves of ore in the district.

The *Essex Mine* (Fig. 29) lies 200 feet southwest of the Independence mine at an elevation of 5500 feet. The workings consist of an open cut from which are driven two short tunnels each about 100 feet in length and a vertical shaft 40 feet deep. The vertical shaft is sunk on a vein 7-20 feet wide, striking N. 65° W., and dipping 85° S. The deposit has formed on the south side of a small lobe of the stock. The vein has several small branches into the tactite and intrusive. Near the bottom of the shaft the vein is faulted. A vertical north-south fault is encountered 25 feet west in a drift driven in the footwall of the fault beyond which tactite is impregnated with pyrite, steely galena, and fluorite. The fluorite is purple and darkens upon lying in the open. The sulphides replace the tactite in very small veinlets and masses. This is one of the few places in the district where sulphides have impregnated the tactite in quantities sufficient to constitute ore. As it is mined, it runs 15 per cent lead and seven ounces in silver. Aside from this occurrence west of the fault in the bottom of the mine, most of the material in the Essex vein is the gossany material similar to that found in the Independence mine. A peculiar vein consisting of white lami-



GEOLOGIC MAP OF THE DEFIANCE-INDEPENDENCE MINE GROUP

BY VINCENT C. KELLEY

SCALE

0 100 200 400

FEET

CONTOUR INTERVAL 50 FEET

N.

JURASSIC (?)
QUARTZ DIORITE

PENNSLYVANIAN
TACTITE WITH SOME IMPURE LIMESTONE

BRECCIATED TACTITE

FAULT

VEIN

nated fluorite carrying considerable galena occurs in a small open cut at the west end of the Essex dump. Fifteen or twenty tons of good sulphide ore are piled near the shaft. In some of this material blue radiating crystals of linarite, the double basic sulphate of lead and copper, have been found.

The *Thompson Mine* is situated about 1000 feet north of the Defiance mine at an elevation of 5300 feet. Access to the principal workings of the mine is gained by a 400-foot tunnel driven N. 65° W. The portal is in quartz diorite and the contact of the tactite is about 260 feet in from the portal. A mineralized zone about 60 feet in width is encountered in the tactite about 350 feet in from the portal of the mine, and most of the stopes are in this ground. The presence and extent of the mineralized zone is determined by a prominent cross fracture which bounds it on the north side. This fracture strikes N. 75° E., and cuts the tactite-quartz diorite contact in the canyon 350 feet northwest of the portal to the Thompson mine, at which point the fracture is heavily gossanized for a width of 10-15 feet, both in the tactite and in the quartz diorite.

The ore consisted of galena, cerusite, pyrite, and sphalerite with calcite, quartz, jasper, and iron oxides. That chalcopyrite is a constituent of the ore is shown by numerous chrysocolla veinlets in the outcrop directly over the principal workings. Unusually large masses of galena were encountered in the stopes and considerable native sulphur occurs as an oxidation product of the lead ores. Unusually coarsely crystalline sphalerite, attaining dimensions of several inches, occurs associated with calcite.

Near the end of the Thompson tunnel a 175-foot raise has been driven to the surface along a prominent cross fracture. Ores from small cuts and tunnels are dropped through this raise and hauled out through the Thompson tunnel. Because of their position between the Thompson and Independence mines, these tunnels are known as the Intermediate mine. The entrance to the main tunnel was entirely covered by debris from a recent cloudburst at the time of the field work. All of the Intermediate workings lie north of the cross fracture and they are located on bedding-plane deposits and smaller cross fractures. Several small tongues of syenite or alaskite intrusives occur near the workings.

The *Defiance Mine* (Figs. 26 and 30) is situated one mile north of Darwin at an elevation of 5250 feet. It is one of the oldest mines in the district and as a producer ranks with the Lucky Jim mine, although the ratio of silver to lead in the Defiance mine has not been as high as that at the Lucky Jim. At the Defiance mine two large lens-shaped orebodies occur parallel to the contact.

The principal orebody crops out along the intrusive contact for a distance of 215 feet and has a maximum thickness of about 40 feet. At the mine the contact of the stock roughly parallels the stratification of the tactites which strike N. 25° W., and dip 35° W. The other orebody lies about 50 feet above the contact orebody along the bedding of the tactites. It is 190 feet in length and 30 feet in its greatest width. About 100 feet above the upper orebody is a sill of quartz diorite 100 feet in

thickness which follows the gently arched tactite in a curve to the north where it joins the main stock near the cook house 250 feet north of the mine.

Thus, the orebodies lie in a curved wedge of tactite between the stock and a branch sill. The northward extent of the orebodies is limited by the sill. It is evident from the underground workings that the orebodies are more extensive to the south than the surface outcrops would indicate. The mine is opened by an inclined shaft in the footwall of the orebody to a vertical depth of about 300 feet. In addition a tunnel 550 feet in length has been driven straight into the hill at the surface level of the mine and considerable ore from the upper orebody was stoped by drifts from this level. Drifts north and south from the inclined shaft have been run at various levels from which the bulk of the ore produced has been stoped.

Most of the veins consist of highly gossanized and kaolinitic material within and along which are found masses of calcite, quartz, pyrite, fluorite, and jasper. In addition, large remnants of limestone and tactite are included in the veins. In the early days of mining at the Defiance mine much of the highly oxidized material of the veins was either left unmined or thrown on the dumps. However, under present conditions of mining and milling much of this would undoubtedly form good milling ore. The calcite of the deposit is exceedingly coarse and cleavage pieces 12-18 inches in diameter are common. Fluorite is also coarse-grained and may be white, lavender, or green in color. Galena and cerusite occur in bunches and small shoots in the highly oxidized material or enclosed in calcite or fluorite with pyrite and dark brown sphalerite. Pyrite crystals ranging from a fraction of an inch up to two inches are very abundant and near the outcrop the walls of the stopes are in places lined with pseudomorphs of limonite after pyrite. Chalcopyrite in small quantities is common with the galena, and as a result chrysocolla and melaconite are to be found near the surface. In places the tactite walls are impregnated with pyrite and sphalerite, the latter often in bands following the stratification. In the future, ore found in this mine will most probably lie to the south of the entrance of the shaft and from a structural standpoint the ground around the breccia tactite south of the drifts on the 215 and 290 levels is the best to explore.

The *Rip Van Winkle Mine* is situated on the west side of the Defiance ridge about 1000 feet south of the Defiance mine. It is opened by a vertical shaft 250 feet in depth along a cross fracture striking N. 45° E. It is one of the few producers from a fissure vein on the west side of the stock. The ore is highly pyritic and is reported to run unusually high in silver. Galena, sphalertie, and pyrite together with considerable calcite and fluorite impregnate the tactite walls adjacent to the fissure. The mine, which is owned by the Darwin Lead Company, has not been worked for many years and was inaccessible at the time of the field work.

MINES IN LANE CANYON

Several mines and prospects occur in Lane Canyon along the highway through the Darwin Hills. The following are described in this section (1) Wonder Mine Group, (2) Standard Extension, (3) Jackass, (4) Santa Ana, and (5) Lane.

Wonder Mine Group. The mines and prospects of this group are situated at an elevation of 4700 feet near the highway about half-way down the Lane grade near the sharp turn in the canyon. The old Wonder mine described by Knopf is situated on the south side of the highway and is located on a deposit which appears to have formed along the bedding of the tactite. The deposit is opened by a short tunnel and a shaft which is inaccessible. The tactite along the deposit is characterized by much vuggy garnet with crystals of quartz and pyrite formed in the cavities. The main gangue of the vein, however, is coarse cleavable calcite intergrown with white, iron-stained fluorite. The ore, chiefly carbonate, is found in this gangue.

North across the Lane canyon are several prospects on the Wonder No. 1 and the Bruce claims. The Bruce prospect is located on a large mineralized area some 50 feet in width and 1200 feet in length. The rocks of the mineralized ground are tactites which dip S. 76° W. at 53°. Two small tongues of quartz diorite occur in the canyon to the north. The tactite is brecciated to some extent and the bedding has been mineralized by calcite, fluorite, quartz, pyrite, and chalcopyrite. A little scheelite has been found and assays of 2.2 per cent tungsten were reported as well as traces of molybdenum.

The *Standard Extension Mine* is located north of the Bruce claims at an elevation of about 4950 feet near the top of the ridge. The deposit is a fissure vein. It is almost directly across the stock from the Independence mine. The workings consist of two tunnels opened up along a fissure which strikes N. 55° E. obliquely across the bedding. The vein is four to eight feet wide and consists of quartz, calcite, fluorite, jasper, and ore mostly in the carbonate form.

Santa Ana Mine. The Santa Ana shaft is located just north of the mouth of Lane Canyon at an elevation of 4450 feet. There are two veins striking N. 40° E. The principal vein to the south is opened by a vertical shaft 200 feet in depth, with a 30-foot winze below the bottom (200) level. Two other short levels have been driven on the vein at 75 and 150 feet. The ore material consists chiefly of powdery iron oxides in which are occasional small siliceous seams. These are reported to run higher in silver. The width of the vein varies from 1-6 feet on the surface to 8-10 feet on the lower beds. The shaft was sunk and most of the development done in the nineties with a geared hand-hoist.

The *Lane Mine* is situated at at the east edge of the hills just south of the Lane Mill at an elevation of about 4400 feet. The mine is opened up by two vertical shafts to a depth of about 800 feet. The deposit on which the mine is located is known as the Lane vein. It is traceable on the surface from the mine westward into the east edge of the stock, a distance of over 3000 feet. In the canyon west of the shaft portals, a tunnel has been driven 1300 feet on the vein. The strike of the vein is roughly N. 65° E. The country rock in the vicinity of the mine consists chiefly of blue-gray limestone, but westward the vein passes through increasingly metamorphosed limestones and into tactites. The vein matter is principally brecciated and gossanized jasper which carried the shoots of primary sulphides and carbonate ore. Chrysocolla veinlets are common in the vein matter on the dump. According to a

recent lessee the lead values give way to copper on the lower levels, and gold values are said to increase with the copper.

The *Jackass Mine* is situated near the eastern crest of the hills at an altitude of 5000 feet. The orebody is on a bedding plane on the west limb of the anticline which occupies the ridge west of the Lane mine. The vein is only 1-2 feet wide in the outcrop where it is exposed in a shallow cut for about 30 feet. Some sulphides, galena, chalcopyrite, pyrite, and secondary covellite, occur in the outcrop disseminated in green garnet-diopside tactite. At the 50-foot level the vein is widened to 8-10 feet and consists of highly pyritized tactite and considerable clay jasper, and hematite stalactitic, while aragonite has filled cracks in many places.

MINES OF THE SOUTH END OF THE DARWIN HILLS

The mines described under this heading all lie south of the highway through the hills.

The *Custer Mine* (Fig. 31) is situated one mile east of Darwin in the canyon next south of Lane canyon, the one through which the state highway runs. The elevation is 4700 feet. The deposit occurs near the tip of a very prominent cross-cutting lobe of the quartz diorite protruding from the east side of the Darwin stock. Knopf (1914) considered the ore to be formed in the broken arch of a fold. As a matter of fact, however, the deposit is located 150 feet west of the axis of the fold along the bedding of the tactites, which strike N. 25° W. and dip 50° W. The steeply dipping tactites in which the ore chimney has formed are cut off 25 feet south of the inclined shaft in the ore by the lobe of quartz diorite. Thus, the deposit is of the bedding-plane type located a short distance from the contact which is in this case approximately normal to the stratification. The inclined shaft is 335 feet in depth with levels at 130, 150, 185, 230, and 310 feet.

The vein minerals in addition to the usual lead ores consist principally of gossany iron oxides, coarse calcite, pyrite, jasper, and fluorite. In addition, garnet appears to be one of the vein minerals and its association with coarse calcite cementing brecciated fragments of the tactite was noted by Knopf (1914). Also, a little specularite hematite is to be found in cavities in the vein. Coarse calcite is remarkably developed on the 200-foot level where it is at least 50 feet thick and 75 feet along the strike. This represents a local swelling in the vein, for above and below this level the calcite body is not nearly as large. Lead ores were scattered through the calcite body in association with iron oxides.

The *Fernando Mine* is situated in the next canyon south of the Custer mine at an elevation of 4600 feet. The deposit occurs at the intersection of a prominent cross fracture and the bedding of the tactite. The mineralization is greater on the cross fracture or fissure vein which is rather persistent and traceable on the surface for about 2000 feet in a direction N. 65° E. The tactites strike N. 15° W., and dip 55° W. An inclined shaft 125 feet in depth has been sunk on the bedding and the deposit opened up therefrom by numerous short tunnels and stopes from several levels. The inclined shaft is intersected by a tunnel

driven along the fissure about 30 feet below the shaft entrance. Along this tunnel considerable displacement is evidenced by brecciation, clay and iron oxide gouge, and well-preserved slickensides. Striations on the fault plane dip parallel to the bedding, i.e., 50°-60° west, the north side having moved down and to the west. The mineralization along the stratification is not confined to one horizon and locally has spread through several closely spaced beds. On the 100-foot level mineralization paralleling the fissure has affected a width of 30-40 feet. The ore minerals are galena, cerusite, and anglesite and the gangue consists of jasper, hematite, much gossany limonite and a little calcite. Galena found in the stopes is coarse-grained and in places imbedded in jasper. Ore shipped from the mine when it was last worked in the late twenties is reported to have carried 30 per cent lead and 30 ounces in silver.

The *Promontory Mine* is situated about one mile southeast of Darwin at an elevation of 5000 feet. The deposit is one of the initial discoveries made in the district. Three closely spaced bedding-plane veins are exposed in the cut behind the shaft. These are in tactite which strikes north and dips 33° W. It is opened by an inclined shaft down the dip of the beds to a depth of 320 feet. Drifts not over 100 feet in length lead to extensive stopes north and south of the shaft. The veins range from a fraction of a foot to 6 or 8 feet and locally more in width. The veins have been subjected to considerable slippage which took place largely along the veins themselves causing considerable gouge material and slickensiding. Some of the movements, however, have been at angles to the veins, but the displacements do not appear to be large. Iron oxides and jasper are the most abundant gangue minerals of the vein, but some calcite and siderite are present. Much secondary calcite in flat rhombohedrons occurs throughout the mine.

The *Silver Spoon Mine* is situated about two miles southeast of Darwin and 3000 feet northwest of the Columbia mine at an elevation of 4500 feet. It is located on a prominent fissure vein which strikes N. 65° E., and dips roughly 80° N. The fissure is traceable for about 2500 feet and at the mine it has been opened up to a depth of 250 feet by a shaft at the bottom of which is a drift 125 feet to the west. The ore is mostly carbonate with a little galena in highly oxidized and siliceous vein matter. The vein varies from one to four feet in width. Ore shipped carried 35 per cent lead and 18 ounces of silver per ton. Some of the ore was evidently crudely cleaned and concentrated by screening on the dump.

The *Columbia Mine* is the southernmost mine in the Darwin Hills and is about 2½ miles from Darwin at an elevation of 4350 feet. It is located on a fissure vein which strikes N. 60° E. and is about 2000 feet beyond the southern end of the Darwin stock. The vein cuts across blue-gray, unsilicated limestone and the mine is one of two in the district which is located outside of the silicate aureole. The vein, which is vertical, has a maximum width of 15-20 feet. It has been worked along the strike for about 200 feet and to a depth of about 225 feet. The chief feature of this vein is the abundance of dense jasper. The lead ores consist of galena and carbonate.

FUTURE EXPLORATION

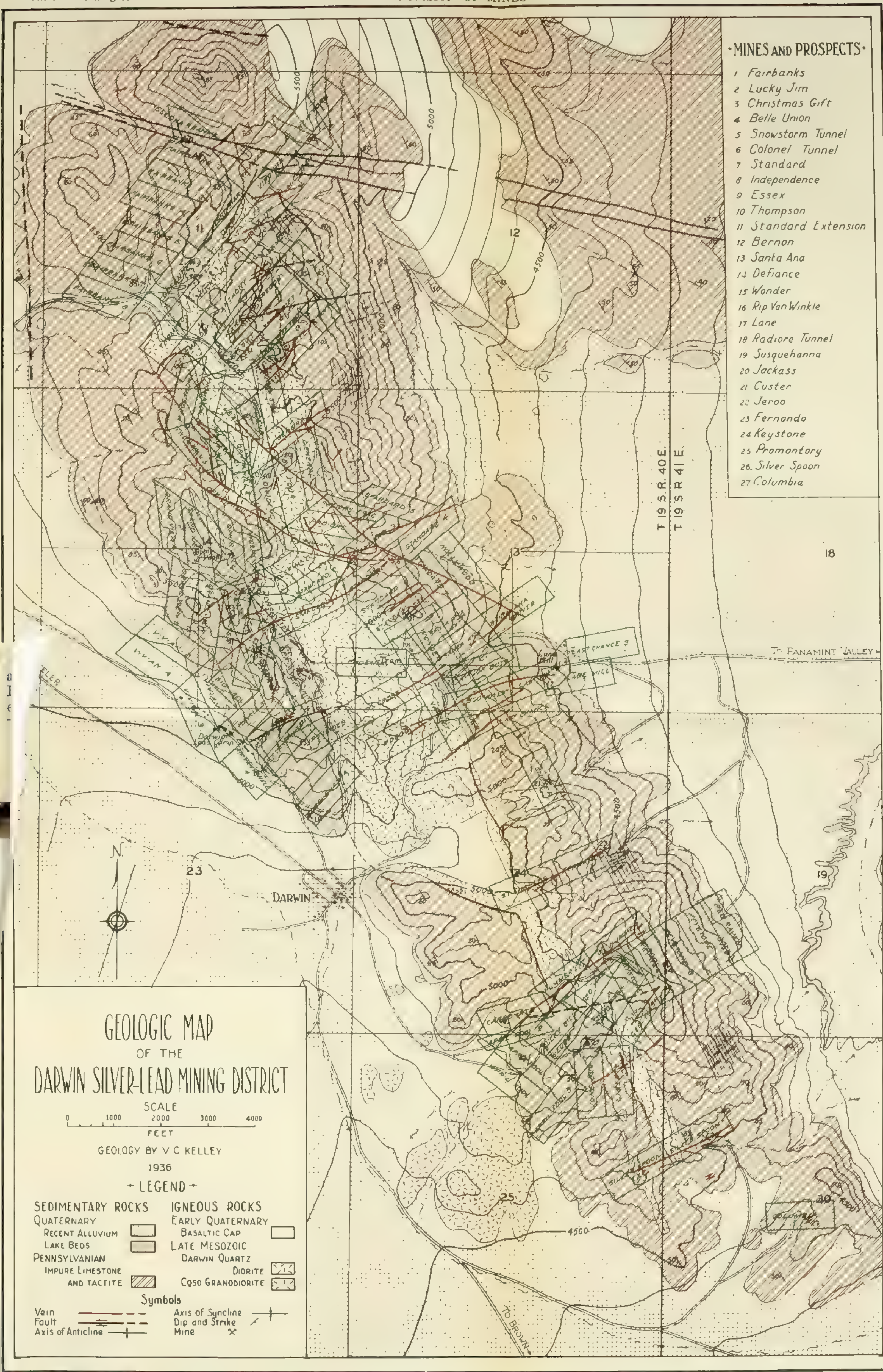
The immediate future of the Darwin district lies almost entirely in mining to greater depth deposits already discovered. Practically all of the production at Darwin has come from within 300 feet of the surface. Successful mining will have to be carried out on a large scale and it will be necessary to keep ores blocked out in advance of extraction if mining operations are to be more than sporadic. Orebodies of the contact type are irregular or bunchy and they may terminate suddenly. New bodies, unless exposed at the surface, are difficult to find and hence considerable exploration and proving of new ore should parallel mining at all times.

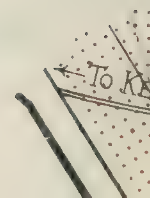
In regard to future prospecting for deposits it should be borne in mind that only the west side of the stock has revealed orebodies at the immediate contact. Deposits at the west contact are pod-shaped bodies which are irregularly distributed along the contact surface. They vary considerably in size but the largest generally exceed the dimensions of fissure or bedding-plane deposits. The entire unexposed contact surface is potential ground for such deposits. Some deposits, like the Independence body, may be exposed only slightly or hidden entirely. In general, it may be found that irregularities or protuberances of the surface of the stock, especially where paralleled by the stratification of the country rock, are favorable loci for deposits along the contact.

Most of the fissure veins are rather persistent, but only certain stretches of the fissures have been sufficiently mineralized to constitute ore. The ore in such deposits makes in bunches or shoots. In the case of the Lucky Jim and the Christmas Gift deposits the ore shoots rake to the west. This may or may not be true for other such fissure deposits. To date the northeasterly trending fissure veins only have produced ore. In a few cases the fissure veins have been dislocated. Although in most cases the displacements have not been large, the usual direction of displacement is the north side westward. The fissure veins are more prominently developed in the tactite zone. The portions of such fissures extending into the intrusive as a rule have not constituted desirable ground.

In the past there has been considerable experimentation and money expended for selecting an entree to the ores beneath the Defiance-Independence ridge. The Radiore tunnel driven through hundreds of feet of barren ground is one evidence. Most of the deposits dip westward under this ridge more or less comformably with the bedding or the surface of the contact of the stock.

A considerable amount of geophysical prospecting by electrical methods was carried on during the late twenties in an effort to locate ore. The writer has had access to some of the maps compiled from such work and in only very few instances were electrical indications plotted which were not evident in the outcrop. The electrical indication obtained may be from bodies of pyrite. This type of exploration may be successful in locating a few deposits of hidden ore. From the high jasper content of most of the deposits it seems that a magnetometer survey might also be useful. However, it is felt that a smaller expenditure in geologic advice in connection with active mining and exploration would be more beneficial.


MINES AND PROSPECTS
1 Fairbanks
2 Lucky Jim
3 Christmas Gift
4 Belle Union
5 Snowstorm Tunnel
6 Colonel Tunnel
7 Standard
8 Independence
9 Essex
10 Thompson
11 Standard Extension
12 Bernon
13 Santa Ana
14 Defiance
15 Wonder
16 Rip Van Winkle
17 Lane
18 Radiore Tunnel
19 Susquehanna
20 Jackass
21 Custer
22 Jeroo
23 Fernando
24 Keystone
25 Promontory
26 Silver Spoon
27 Columbia
T 19 S. R. 40 E.
T 19 S. R. 41 E.
To PANAMINT VALLEY
DARWIN
TO BROWN
N
GEOLOGIC MAP
OF THE
DARWIN SILVER-LEAD MINING DISTRICT
SCALE
0 1000 2000 3000 4000
FEET
GEOLOGY BY V C KELLEY
1936
LEGEND
SEDIMENTARY ROCKS
QUATERNARY
RECENT ALLUVIUM
LAKE BEDS
PENNSYLVANIAN
IMPURE LIMESTONE AND TACTITE
IGNEOUS ROCKS
EARLY QUATERNARY
BASALTIC CAP
LATE MESOZOIC
DARWIN QUARTZ DIORITE
COSO GRANODIORITE
Symbols
Vein
Fault
Axis of Anticline
Axis of Syncline
Dip and Strike
Mine



SULPHUR DEPOSITS OF INYO COUNTY, CALIFORNIA

By Edward D. Lynton, Glendale, California

INTRODUCTION

There are two well-defined sulphur-bearing areas on the west slope of the Last Chance Range in Inyo County, California. The most important is covered by the Crater Group of six claims and adjoining claims; the other is covered by the Black Sulphur, Yellow Sulphur, and Sulphur claims, 12 in all, and lies about 1½ miles east of the first group.

Sulphur in Inyo County is reported to have been discovered in 1915, by Frank and Dan Hicks of Lida, Nevada, who kept up the assessment work annually on the claims. In June, 1929, an option was taken on the Crater and adjoining claims of the Southwest Sulphur Company by the Pacific Sulphur Company, who expended about $45,000 in development work, consisting of an inclined shaft 200 feet deep, with cross-cuts on the 100-and 200-foot levels. In addition, they put down 11 churn drills on the various properties.

In June, 1932, various leasers worked the claims and shipped high-grade ore to Los Angeles. The first were Sanger and Albertoli of Big Pine, California; they were followed by Smith Brothers, the West Coast Sulphur Company, and Sulphur Diggers, Inc., all of Los Angeles. They shipped in all over 30,000 tons averaging 75 to 80 per cent sulphur to one of the chemical plants in Los Angeles. Shipments by the West Coast Sulphur Company, totaling 12,000 tons, averaged better than 83 per cent sulphur. The cost of the mined sulphur, f.o.b. Los Angeles, was $13 per ton. The Sulphur Diggers, Inc., ceased work in September, 1937, and the properties are now held by the Western Mining Company of Los Angeles.

ACKNOWLEDGMENTS

Acknowledgment is here made to Mr. and Mrs. Stewart of the Stewart Ranch at Oasis for the many courtesies extended to the writer; to Mr. F. B. Mechling, who furnished the logs of the churn-drill holes; and to Messrs. Frank and Dan Hicks for information on the various properties; also to Mr. G. L. Knox, who assisted in the sampling, and to Mr. L. L. Tabor, who continued a study of the geology of the region intermittently for two years, during which time he collected much valuable information which he has kindly furnished to the writer.[1]

LOCATION

The Crater Group of sulphur claims is located partly in Secs. 33 and 34, T. 8 S., R. 39 E., M.D., on the west slope of the Last Chance Range, which separates the Eureka Valley on the west from the north end of Death Valley on the east. These claims were tied in by triangu-

[1] Personal communications.

lation to a Government survey stake of 1884. As such ties are very scarce in this region, and as this tie was found only after considerable effort, a description of its location is inserted here:

As the road from Oasis to Crater leaves the easterly side of the Eureka Valley, it climbs up steeply for about 0.3 of a mile before entering the long canyon grade to the mine. At the entrance of this canyon the road bends sharply from the north to the east.

From this bend walk 2,000 feet south to the first long, most prominent terrace; on the south slope of a small saddle at its western termination, the Government stake will be found.

The markings on this 53-year old stake are those used by the General Land Office surveyors during that time, and are as follows:

1. The northwest side of the stake is marked "S. 25."
2. On the north corner are five notches, indicating that it is five miles north to the township corner.
3. The northeast side of the stake is marked "S. 30."
4. The southeast side of the stake is marked "R. 39 E., T. 8 S."
5. On the south corner of the stake there is one notch, indicating that the township corner lies one mile to the south.
6. The southwest side of the stake is marked "R. 38." The rest is undecipherable.

The above inscriptions indicate that this stake is the southeast corner of Sec. 30, T. 8 S., R. 39 E., M.D. This monument is on the township line dividing Ranges 38 and 39 East.

At the present time the sulphur deposit can only be reached via a fair desert road from the town of Oasis, a distance of about 28 miles, which can be traveled in about 1 hour and 20 minutes. Oasis, on the main road between Big Pine and Tonopah, is 40 miles northeast of Big Pine, California, over a well graded, partly oiled mountain road. The nearest railroad point is Zurich, a station on the branch of the Southern Pacific that runs from Mojave up the Owens Valley to Tonopah. The distance from the deposit to the railroad at Zurich is 68 miles by the present road.

MAPS

Crater Claims (Fig. 1)

This property consists of six unpatented claims, known as the Crater Group, and covers about 125 acres. The most valuable of the claims are Crater Nos. 1, 5, 2, and 6.

Fig. 1 shows the detailed survey of the claims. A true north line was established from a fixed station by a sight on Polaris on the nights of January 18 and 19, 1932. This station was found to be in Lat. 37° 14′ 42″ and Long. 117° 42′ 42″ east of Greenwich. The magnetic variation was found to be 16° 50′ east of north.

General Map of Claims (Fig. 2)

This map shows the claims which have economic importance, and the relation of the group to the sulphur bearing area to the east (the Black Sulphur, Yellow Sulphur, and Sulphur groups) before the amended locations were made.

Black Sulphur Claims (Fig. 3)

This map shows the amended location of the eastern group of claims. The claims follow the trend of the faulted zone which carries sulphur. While pits and trenches show the presence of a good grade of sulphur, insufficient work has been done to prove whether the occurrence

is local or continuous. The author believes that commercial sulphur is present in isolated bodies, but considerable exploration work will have to be done to outline the economic areas.

These claims were tied into the Crater Group by stadia survey with the corrected section corners shown.

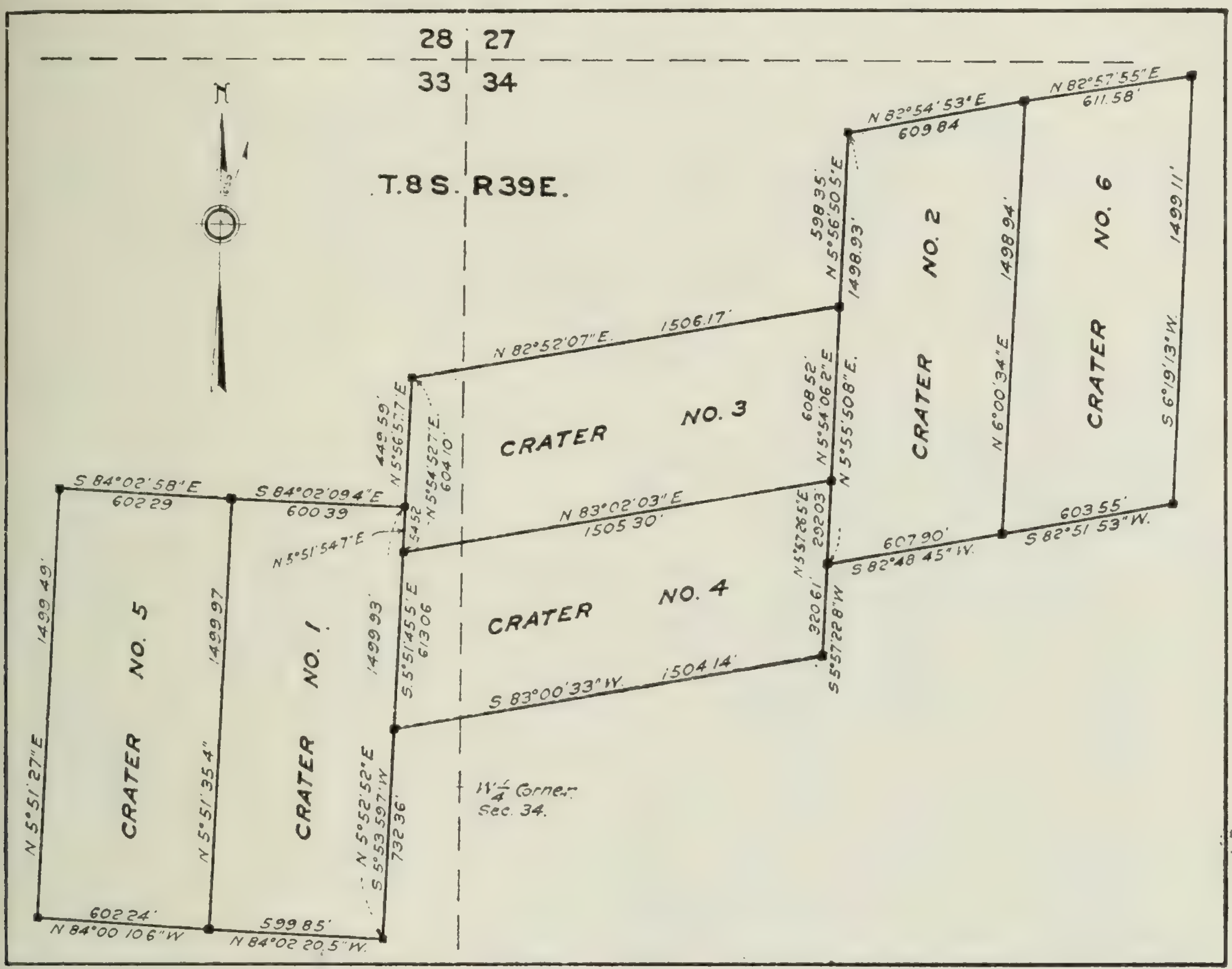


FIG. 1. Claim map of Crater Group of claims, Inyo County. Transit and chain survey by E. D. Lynton and L. L. Tabor, January, 1932.

Geological Map (Fig. 4)

This is a topographic and geologic map of a part of the Last Chance Range, with special reference to the Crater Group of claims. It shows the general geology, the main faults to which mineralization is related, and the several mineralized zones of economic importance. The open-cut pit on Crater No. 2 claim is roughly outlined. This mining operation was carried on from 1933 to 1937, subsequent to the time of the mapping.

Sample Map, Crater Mine (Fig. 5)

This map shows an east-west section through the 200-ft. shaft on the Crater No. 1 claim, and a plan of the workings, giving the relationship between the work on the different levels. All the sample localities and the grades of sulphur are also indicated. The tunnel dump, which was thoroughly sampled, averaged 20 per cent sulphur. The associated rock is of a highly siliceous nature, running 70 per cent SiO_2.

Cross-Section of Ore Body (Fig. 6)

This sample map of the Crater No. 1 ore body shows plan, sections, percentages of sulphur, and tonnage of ore in sight. The churn-drill

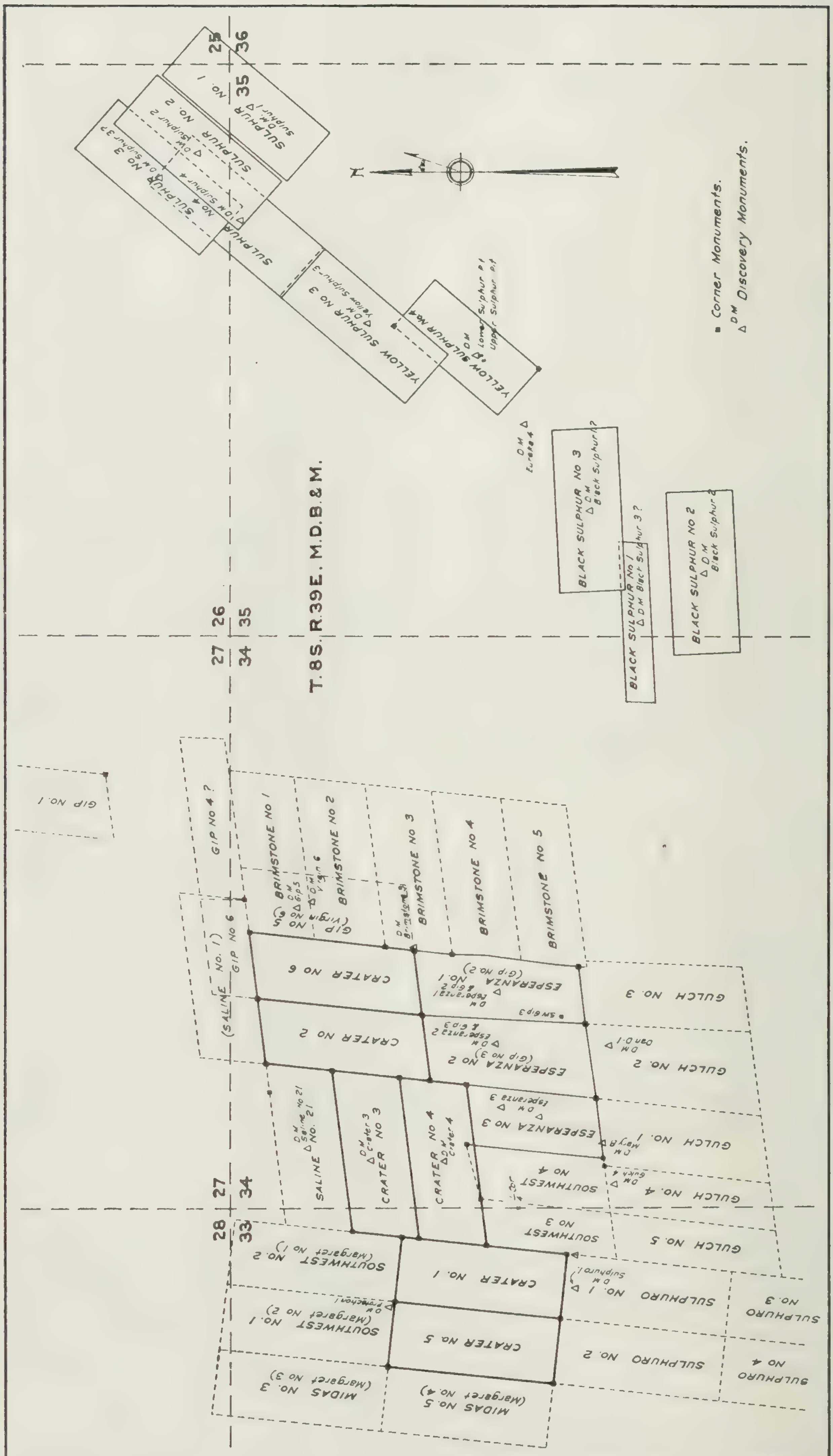


FIG. 2. Crater claims, adjacent claims, and Black Sulphur, Yellow Sulphur, and Sulphur groups, T. 8 S., R. 39 E., M. D. Survey by E. D. Lynton and L. L. Tabor, January-February, 1932.

holes are also shown as they entered and passed through the orebody.

From the sections and drill holes through the orebody, the tonnage and grade of ore in sight were calculated. There is a total length of over 900 feet of ore in sight, with varying widths. Over 250,000 tons of 40+ per cent sulphur is in sight in this small area. The 40 per cent grade could be materially increased by sorting.

TOPOGRAPHY

The Last Chance Range is typical desert mountain country—steep, rugged, and cut by numerous narrow canyons. At the mouths of these canyons the alluvial material is spread into fans consisting of sand,

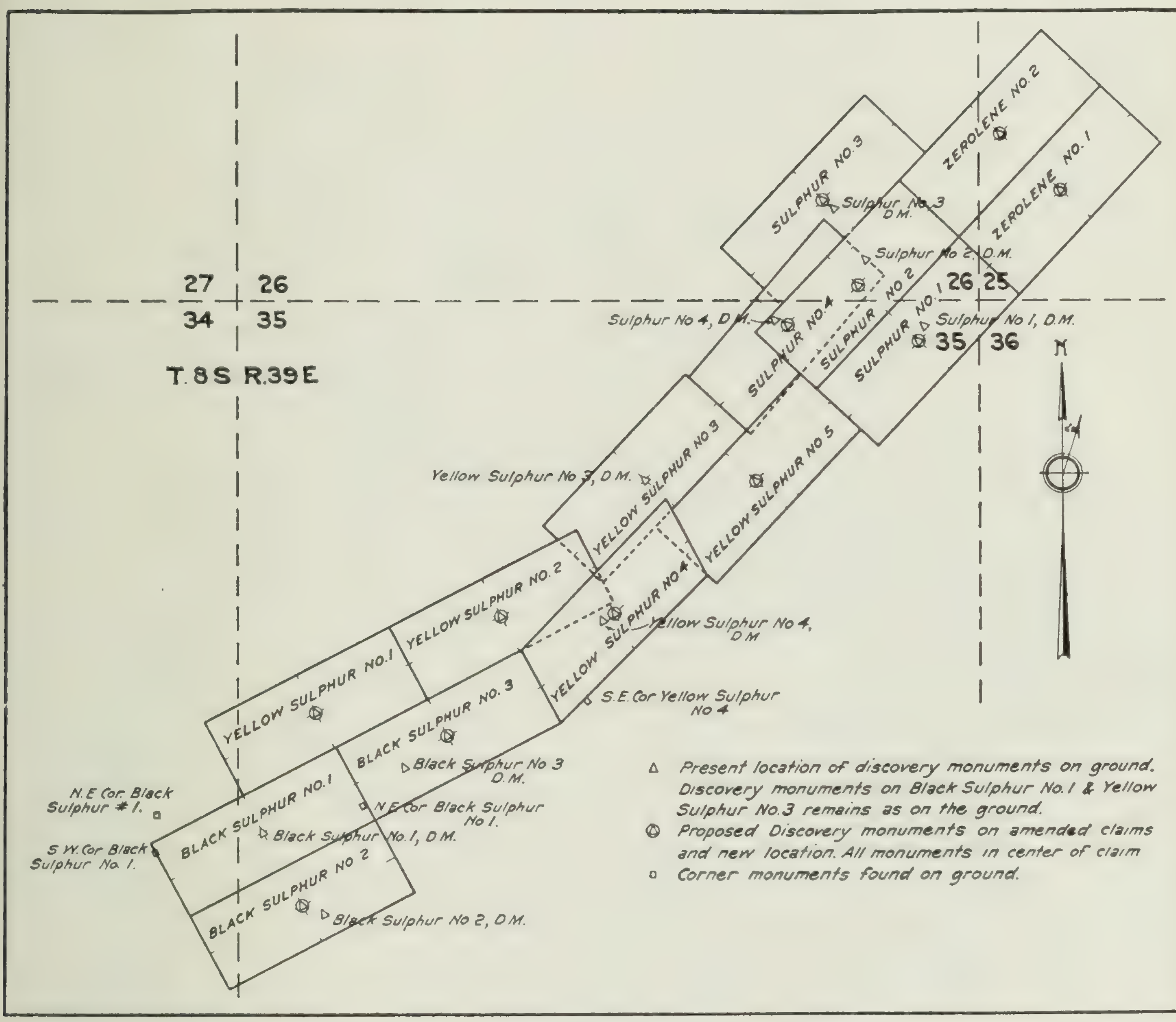


FIG. 3. Proposed amended location of Black Sulphur, Yellow Sulphur, and Zerolene groups, T. 8 S., R. 39 E., M. D.

gravel, and large boulders. The smaller detrital material has been washed down onto the floor of Eureka Valley, so that it can not be traversed by automobile unless a road is scraped.

This region is one of interior drainage. No streams that rise within it carry contributions to the ocean; the snow and rain that fall within it are returned to the atmosphere by evaporation, either directly from the soil, or after they have found their way into some of the sinks in the irregular surface.

Eureka Valley and the north end of Death Valley, which separate certain mountain ranges, are absolute deserts, totally destitute of water and trees, except for gray sagebrush and some mesquite. Eureka Valley

has in its lowest depression, at an elevation of 2,960 ft. above sea level, a playa left by the evaporation of intermittent waters. A shallow well sunk in the center of this playa might obtain water.

Climatic characteristics are excessive summer heat, and dryness. The temperature rises occasionally to 125°F. in the shade, rarely falls below 70° at any time during the five hot months, and averages over

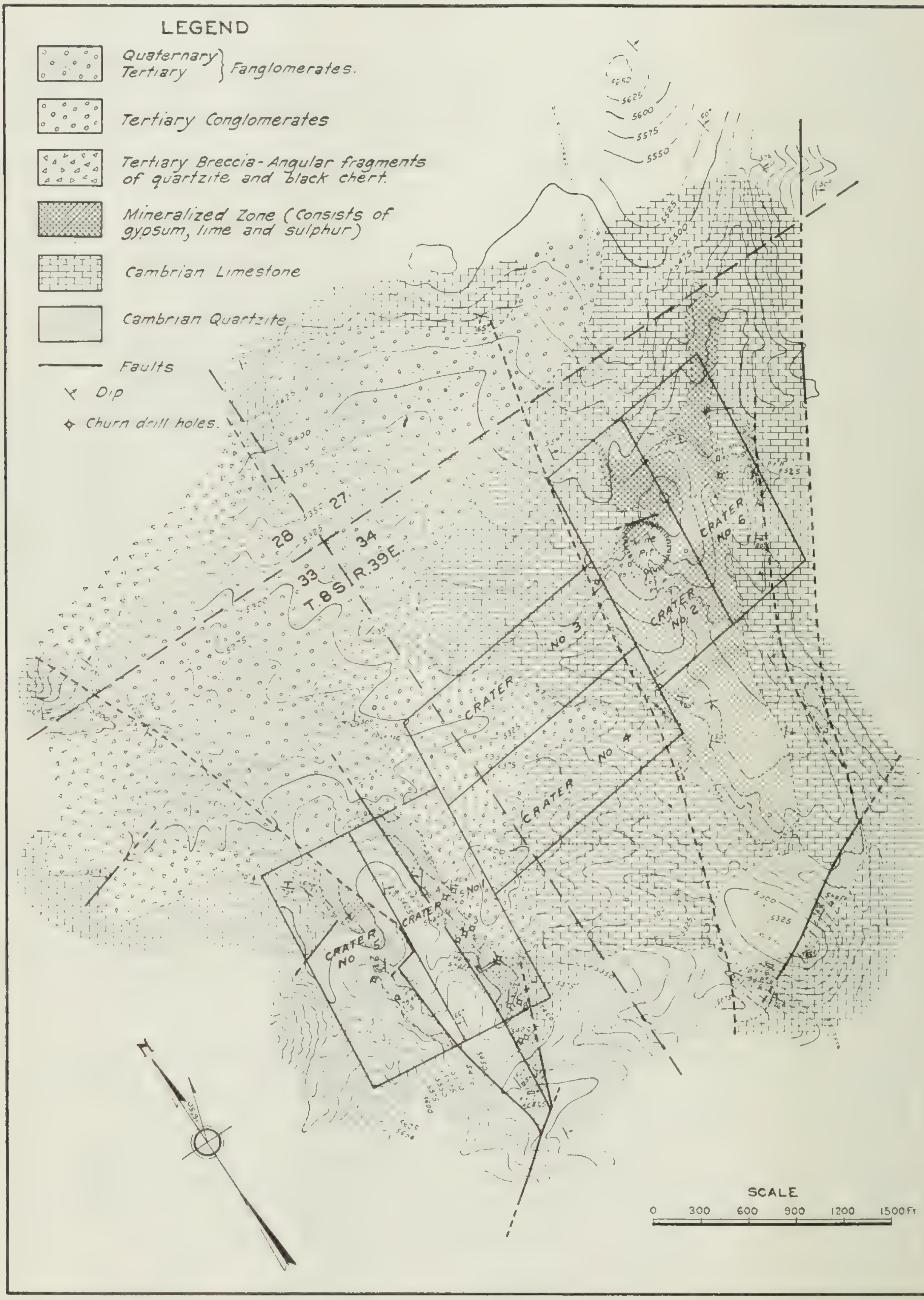


FIG. 4. Topographic and geologic map of a part of Last Chance Range, showing Crater Group of claims, Inyo County, T. 8 S., R. 39 E., M. D. Topography by G. L. Knox; geology by E. D. Lynton.

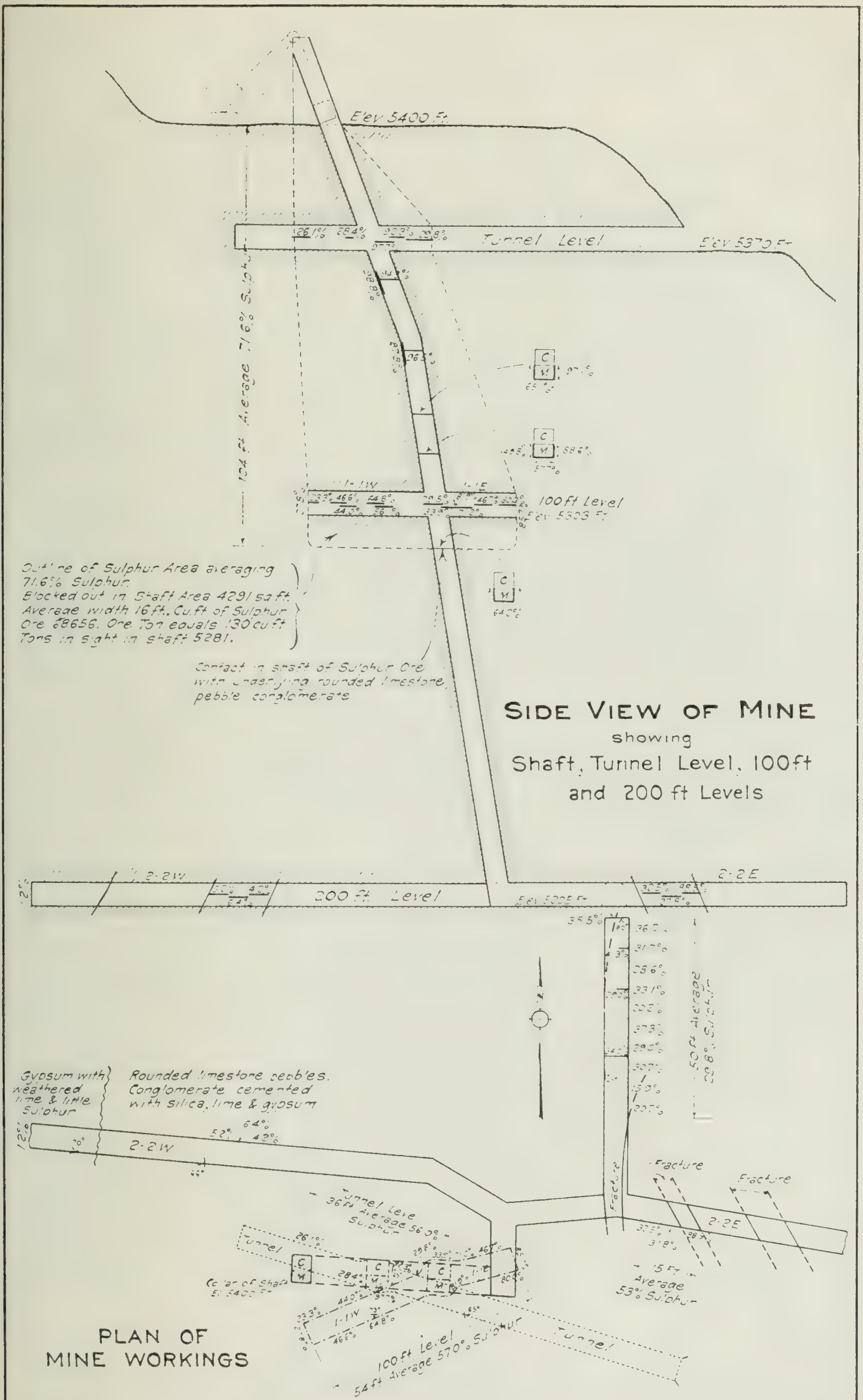


FIG. 5. Sample map of shaft and cross-cuts, Crater Group of sulphur claims, Last Chance Range, Inyo County.

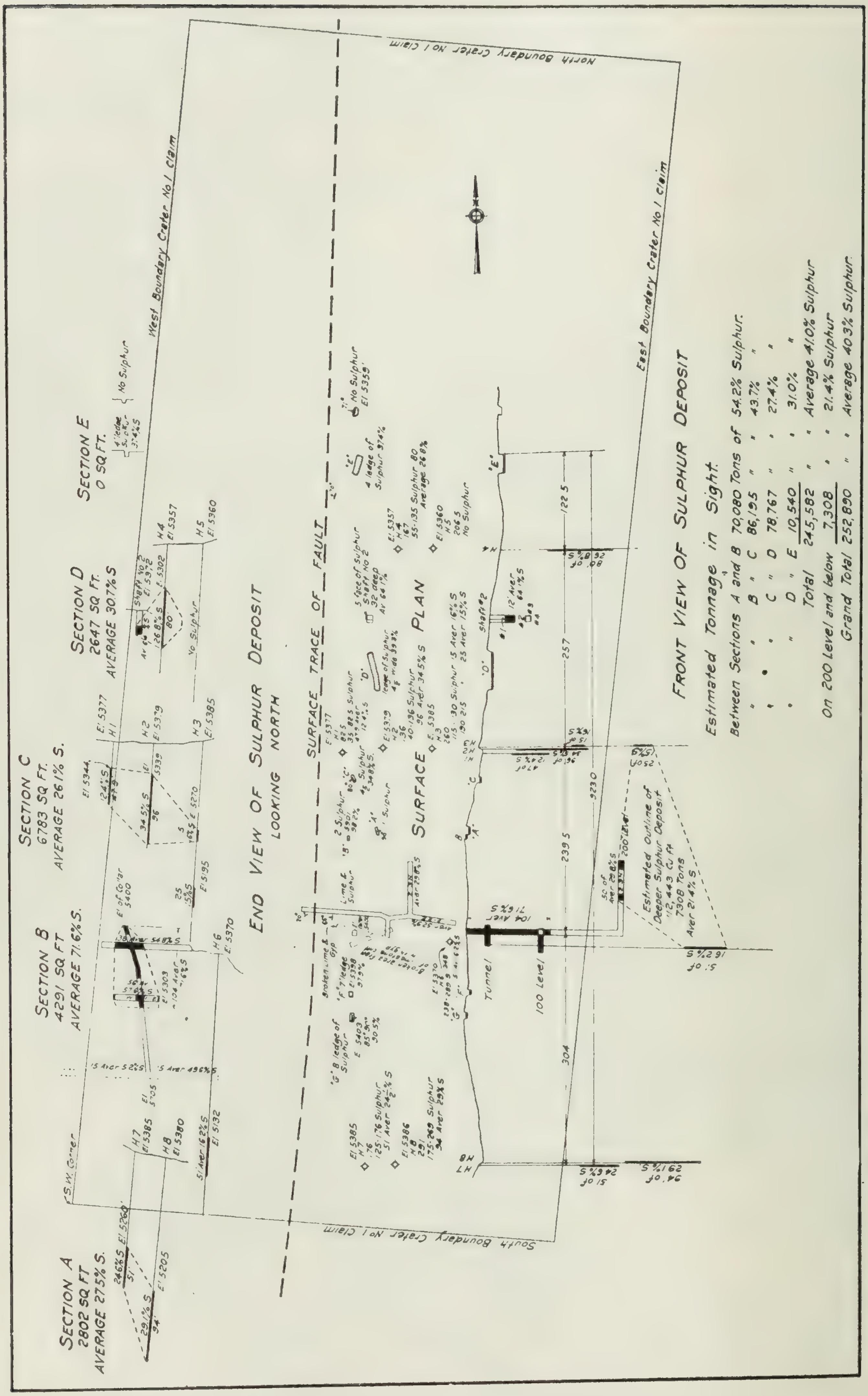


FIG. 6. Sample map of Crater Group of claims showing plan, sections, percentages and tonnage of sulphur ore in sight.

90° during this period. In winter the temperature may reach 85° or 95° F. during the day, and fall to the freezing point before midnight.

ELEVATIONS

Elevations above sea level were obtained at the sulphur deposit and at Last Chance Spring by means of repeated observations with an altimeter from the U. S. G. S. Bench Mark at Oasis, whose elevation is recorded as being 5,031 ft. above sea level.

The following elevations are the averages of several readings:

Oasis B. M.	5,031 ft. above sea level
Top of divide, 10 mi. SE of Oasis	5,606 ft. above sea level
Eureka Valley (lowest point on road)	3,536 ft. above sea level
Old cook house at sulphur deposit	5,277 ft. above sea level
Collar of shaft	*5,389 ft. above sea level

*(This was taken as 5,400 ft. for the planetable survey.)

ROADS AND OTHER FACILITIES

From the railroad at Zurich, in the Owens Valley, there is at present only one good road to the property. It goes northeast 40 miles from Zurich to Oasis, which is the approximate half-way point to Tonopah, Nevada. From Oasis, the road goes southeast 14 miles, where it meets the old Big Pine-Willow Springs-Lida road. About two miles southwest of this junction point, at the eastern border of Eureka Valley, the Pacific Sulphur Company built a road 12 miles long to the sulphur deposit.

Timber is not at all plentiful. Scrub pine can be cut and hauled to the property at a considerable expense from the ranges to the west. All squared timber would have to be hauled from the railroad. However, very little timbering would have to be done on the property, as the type of ground, because of cementation with the sulphur, stands up well.

GEOLOGY

The lowest exposed formation at Crater is white quartzite. The next overlying formation is a red, brittle, mottled limestone exposed in erosional patches. As one enters Hanging Rock Canyon on the road from Eureka Valley, this reddish limestone can be seen on the south shoulder. It is overlain here by a whole cliff of west-dipping, indurated, dark gray-brown shales, grits, gravelly conglomerates, and thin, brown quartzite bands. This, in turn, is overlain by green-gray, bluish slates with fine sand and tuffaceous streaks and indurated gravelly conglomerates, so prevalent in the northern Crater area. There are many occurrences of limestone lenses in these blue slates. These lenses are interesting because they contain minute fossils which in section look like crinoid stems. Overlying these slates are the black limestones. Presumably, everything from the white quartzite up to and including the black limestone is Paleozoic. The white quartzite is very similar to other quartzites which have been classified as middle (or upper?) Ordovician.

The Tertiary at Crater apparently includes limestone breccias, conglomerates, some rubbly sandstone, and volcanics; but it is impossible to ascertain the relative superposition of these materials, except that the breccia may be lower Tertiary despite the fact that it is not altered by the volcanics. The conglomerates seem to have preceded the volcanic action as evidenced by their alteration at the shaft on Crater No. 1

claim. The gravelly sandstone, mostly loose or unconsolidated, exposed southeast of the shaft, may be younger than the volcanics. It is believed to be closely allied to some of the fanglomerates sloping into Eureka Valley.

The volcanics consist of pyroclastics (tuff and breccias), possibly thin rhyolitic flows, and a small intrusive at the shaft consisting of

FIG. 7. Reddish altered rhyolite on Crater No. 2. claim. Because of its circular shape, the name Crater was given to this area.

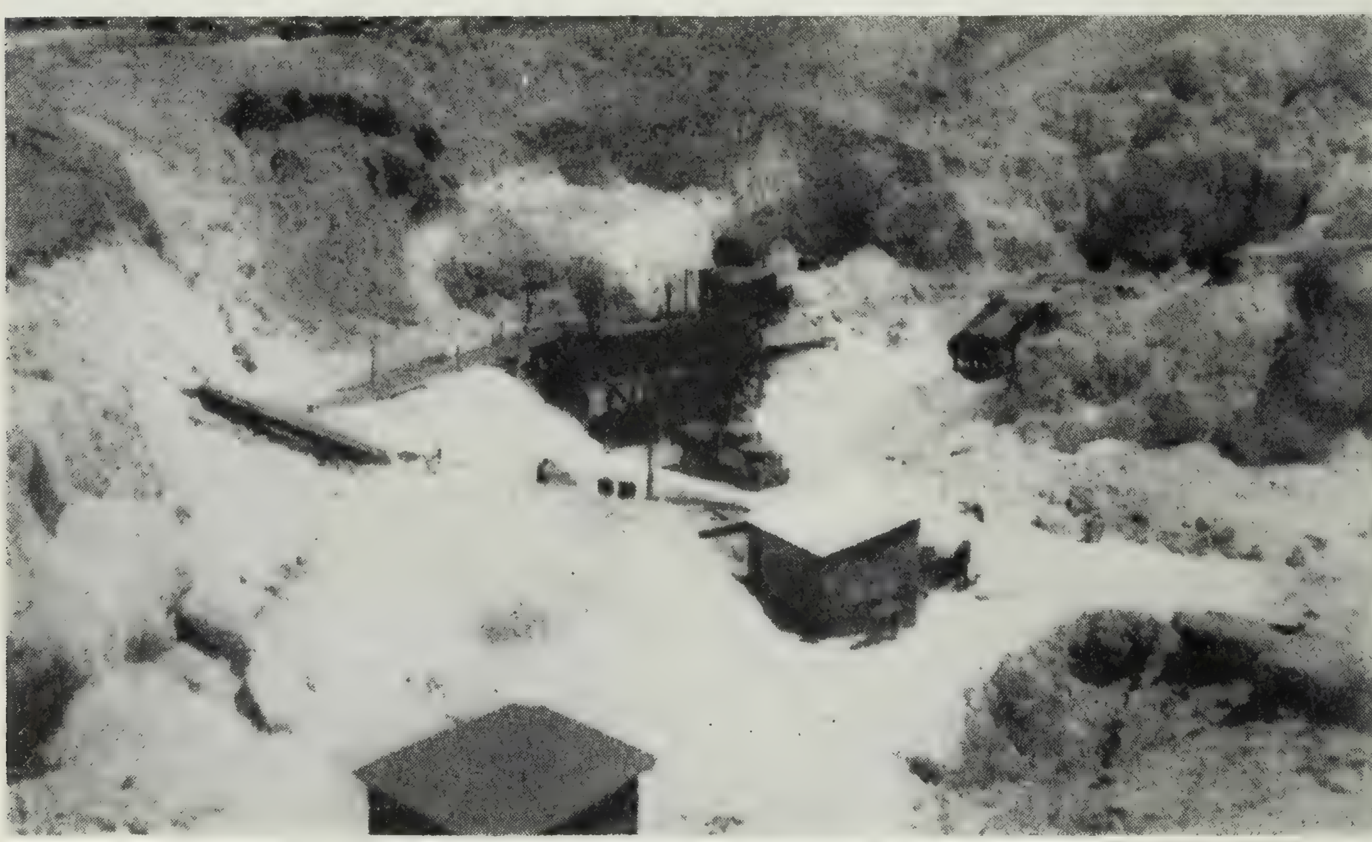


FIG. 8. Mine pit on Crater No. 2.

chunky gray rock, very hard, with dark elongated nodules. A thin section of this intrusive rock shows the texture of an acid intrusive.

Petrographic work has been most difficult owing to the extreme alteration of some of the rocks. In some cases, about all that is left to

go on is the original texture.[2] The shaft rock, that platy white material, is doubtless a rhyolite, and judging by the flow lines in it, is probably in the form of a shallow intrusive. The gray, chunky rock at the collar of the shaft is the same shallow rhyolitic intrusive, either in dike, or irregular stock form. The shaft passes out of this rhyolite (and high grade sulphur) at 108 ft., into a conglomerate. The No. 6 churn drill hole at the mouth of the tunnel shows the following:

0′ — 22′	Detritus
22′ — 85′	Conglomerate
85′ — 322′	Sulphur, gypsum, "chert" (interpreted as altered rhyolite)
322′ —	Conglomerate

FIG. 9. Hanging Rock Canyon. On road from Eureka Valley to Crater mine, showing white quartzite rocks.

The shaft and drill hole data suggest a steeply east-dipping rhyolite intruded through the conglomerate. The rhyolitic material is so badly altered that it is almost impossible to tell exactly what it is.

There is a sparse outcrop between the shaft and the pitted hillside south of the shaft, of brick-red pyroclastic material strung out linearly from the shaft to a point about 500 ft. south. The dip is 75° east.

[2] Personal communication from L. L. Tabor to the author.

This outcrop is just south of the main north-south fault through the shaft.

On Crater No. 2 claim, south of the open pit, is a prominent outcrop, circular in shape, of reddish material badly altered. It is probably a rhyolite, but its groundmass is micro-felsitic, and the few phenocrysts in it have unfortunately gone over to secondary fillings.

The large gulch that empties on the flats just west of the original cook house has several interesting outcrops in it. Down toward its mouth, the blue slates, in places altered to a white powder, are standing almost vertical and striking northwest. Around the first main bend in the gulch, on the west side, is a thin layer of fossiliferous limestone. The next outcrop of interest is at the little falls a few hundred feet farther up. The rock there is a faintly bedded, dense, light bluish-gray formation which is probably igneous. Above this outcrop is the hard, dark brown metamorphosed conglomerate.

FIG. 10. Looking westerly across Crater Group of claims towards mine shaft. Quartzite ridge in background.

On the west side of the high quartzite ridge which forms the westerly boundary of the area, there is a section exposed which helps to unravel the salient points of the stratigraphy of the area. The top of the section, beginning at the east edge of the alluvial material of Eureka Valley, is none other than the blue slates, the same ones exposed from Hanging Rock up to the old camp along the road. The base is the white quartzite of the quartzite ridge. In between there is a nondescript, although well-bedded, series of metamorphosed sediments including sandstones, shales, and gravelly conglomerates. Their base is covered by patches of impure dark limestone, in which no fossils have yet been found. These limestones, in patches, rest on the quartzite of the ridge, and can be seen on the top of the ridge.

The geologic map, Fig. 4, is only a generalized one, as its primary purpose is to tie in the mineralized areas with the faults and associated rocks.

STRUCTURE (Fig. 11)

Structurally, the region is anticlinal. An east-west section through the shaft on Crater No. 1 claim starts on its westerly side in west-dipping beds, flattens on top of the quartzite ridge, and begins dipping east and northeast on the east side of the ridge. The structure is badly faulted, and so this relation is anything but a textbook picture.

The main faults, starting on the west, are: (a) a north-south fault through a point half-way down the east flank of the quartzite ridge; (b) a shattered zone north-south through the shaft, that may connect to the north through the knob above the main road to camp; (c) the fault just west of the mine pit along the easterly boundaries of Crater No. 3 and No. 4 claims; and (d) the large, prominent north-south fault at the base of the black limestone ridge east of the Crater Group of claims. There are many other faults, but these are the main ones, all of which bear some relationship to the mineralized zone.

A general glance at this east-west section suggests a large collapsed arch, with the implication that the black limestones ought to be found somewhere under Eureka Valley. These black limestones seem to be disconformable on the slates. There is reason to believe, however, that these limestones have been thrust westward over the slates, and that normal faulting occurred later, almost completely masking the thrust. The effects of normal faulting are what impress one at Crater, and it may be that these effects are so predominant that they tend to unduly minimize the results of possible thrusting.

The north-south faulted strip to the west of the shaft is so disturbed that it can only be generalized. On the south end of this strip are patches of red limestone resting directly on the white quartzite. From the way these overlying rocks disappear to the south, it seems as if the whole section must be dipping northeasterly, as the dips farther north indicate. In that case, if the red limestone is continuously exposed, or, rather, if it wholly underlies the quartzite, one would expect to see it describe a graceful arc around the rims of the limiting gulch to the south, but it certainly does not. It lies in the most amazing places, and the only possible explanation is a system of faulting which one would be reluctant to describe without painstaking detailed work. Faulting, however, is very prominent, as indicated by the many fault breccias, fault saddles, fault scarps, and slickensides in the area.

ORIGIN AND OCCURRENCE OF THE SULPHUR

Mineralization was at least as recent as the Tertiary, as there is little doubt that the conglomerates in the shaft are of Tertiary age. The apparently different rocks in the vicinity of the sulphur outcrops are nothing more than hydrothermally, or pneumatolitically altered material. This alteration was brought about by means of gases or vapors emanating from the late basalts and other eruptive rocks.

The origin of the sulphur is no doubt of two types: leaching of the gypsum with which the limestones in the area are impregnated; and solfataric action. The association of sulphur with gypsum and organic matter suggests their genetic relationship, since sulphur can be formed by the reduction of gypsum. Organic matter reduces gypsum ($CaSO_42H_2O$) to CaS_2, which, acted on by carbonic acid waters, yields $CaCO_3$ and H_2S (hydrogen sulphide gas). The oxidation of the

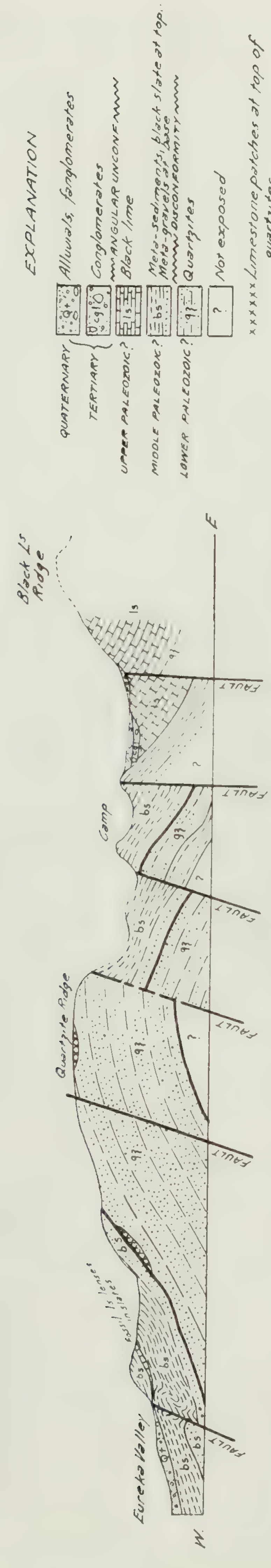


FIG. 11. East-west geologic section from Eureka Valley through Crater sulphur deposit, Inyo County, after L. L. Tabor.

H_2S or the interreaction of the H_2S and SO_2 produces the sulphur. The deposition of sulphur by solfataric action is due to the incomplete oxidation of H_2S escaping as an emanation from cooling magmas. This theory is supported by the presence of volcanic rocks in the area.

The sulphur is intimately associated with fault zones. The north-south fault zone across the Crater No. 1 claim is the only one on which any extensive development work had been done up to 1932. The sulphur is sometimes almost pure in the center of the ore body, but along the edges it is mixed with altered rhyolite. The sulphur does not extend either into the quartzite or into the conglomerate to the east except for a few isolated stringers found on the 200-ft. level. The limits of the sulphur can generally be determined, as the percentages drop off rapidly.

The largest mineralized zone, outlined on surface evidence, occurs only on the eastern edge of the area, running through Crater No. 2 and

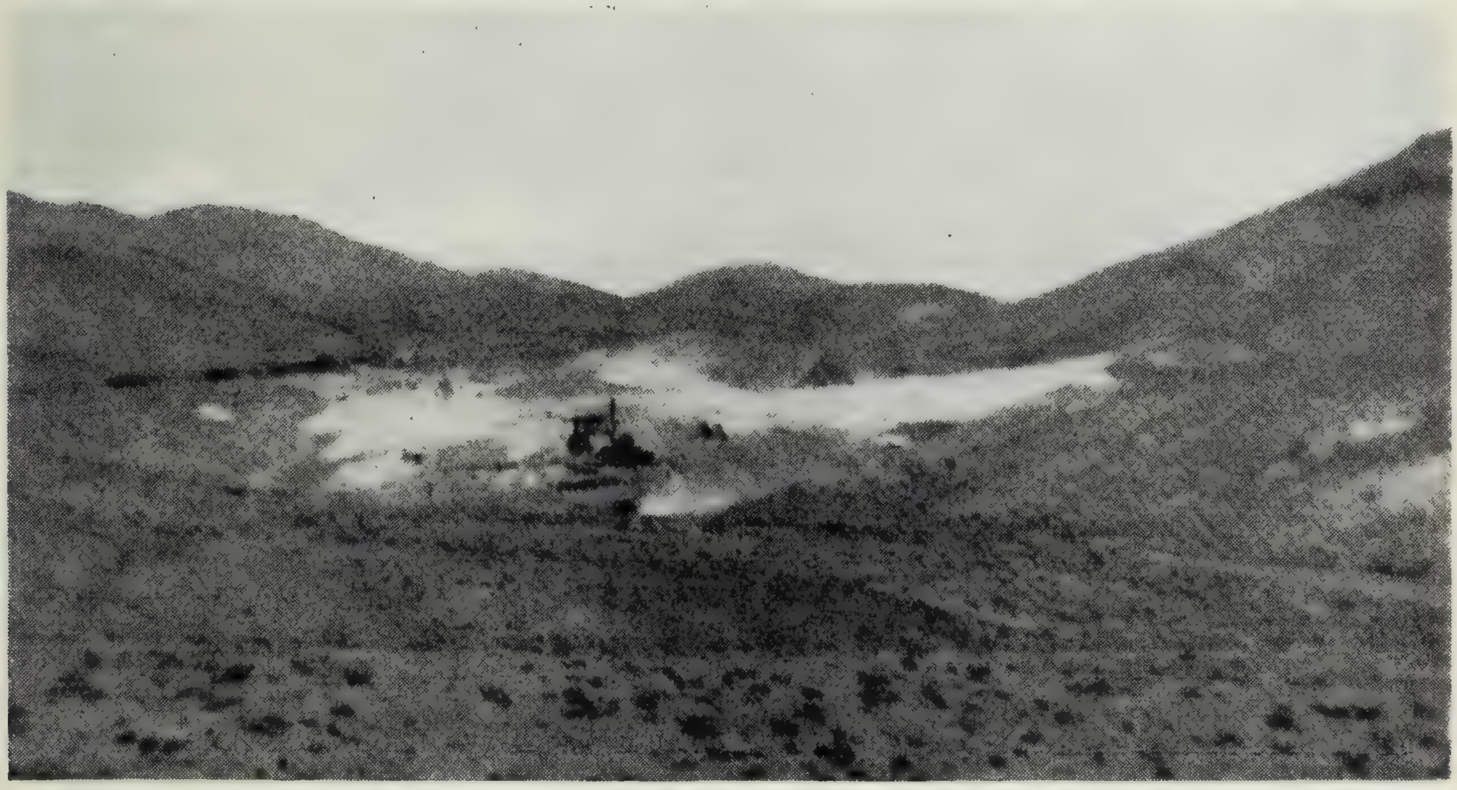


FIG. 12. Looking due north up Main Creek across Crater No. 2 and 6 claims, showing mineralized zone, refinery, and black limestones on east.

No. 6 claims. It is quite distinct and forms a belt between two prominent north-south faults in limestone. Several pits show a good grade of sulphur, and mining operations from 1932-1937 revealed the presence of a good grade of sulphur. The flat-lying beds of sulphur in the pit suggest that hot waters, after rising vertically through a vent, spread out horizontally, changing gypsum in the surrounding limestone to sulphur, as limestone is most prevalent around this particular deposit.

MINING OPERATIONS

Crater No. 1 Claim (Fig. 5)

Shaft No. 1: The main development work consists of a two-compartment shaft 7.55x5 ft., which starts at an incline of 70°, and at a depth of 56.4 ft. changes to an incline of 81°. The depth on the incline is 200.5 ft., making a true vertical depth from the collar to the bottom of 195.3 ft.

From the collar of the shaft, at a vertical depth of 30.35 ft., is the floor of a tunnel which is 78 ft. long and bears S. 72° E. to the portal. The tunnel continues for a distance of 35 ft. on the same bearing, toward the footwall on the west side of the shaft. This tunnel cuts across the sulphur orebody for a distance of 36 ft., the highest grade sulphur being around the shaft. At a vertical depth of 96.56 ft. the 100-ft. level is located. Cross-cuts 34 ft. and 20 ft. have been made west and

FIG. 13. Looking north from Crater No. 1 shaft along mineralized zone, showing sulphur pits and No. 2 shaft.

FIG. 14. Crater No. 1 mine shaft and dump.

east, respectively, from the shaft, all in good ore, total exposed width being 54 ft. At a depth of 108 ft. the sulphur ore is sharply cut off by the conglomerate. The bottom of the shaft, at a vertical depth of 195.3 ft. from the collar, is the 200-ft. level. The most extensive drifting has been done on this level, total footage being approximately 287 ft. Of the various cross-cuts, only the two designated as 2-3N. and 2-2E.

encountered any ore. Cross-cut 2-3N. followed a fractured zone for 50 ft., which averaged 29.8 per cent sulphur, and 2-2E. cut across 15 ft. of ore averaging 53.0 per cent sulphur. The other drifts are all in conglomerate, which does not carry any sulphur.

Shaft No. 2: This shaft is located about 425 ft. north of No. 1, and is only 32 ft. deep, with dimensions of 9 x 3 ft. At 18 ft. below the collar, it enters the sulphur orebody, and the bottom is still in it. The grade of sulphur here is very good, averaging 64.1 per cent sulphur for the 14 ft. exposed.

In addition to the above two shafts, seven large pits or trenches have been dug on the outcrop that strikes almost north and south, and has an apparent dip of 70° east. Other smaller additional pits tend to indicate that the sulphur outcrops definitely along the fault for a distance of 923 ft. The total length of the mineralized zone may be as much as half a mile, but only over this actual distance of 923 ft. has sulphur been exposed.

Churn Drill Holes: Altogether, eight churn drill holes were put down on this mineralized zone on the Crater No. 1 claim. They were sunk to depths varying from 82.5 ft. to 346 ft. One of them, No. 5, was sunk in the footwall and is the only one that did not encounter sulphur, while No. 2 had 96 ft. of sulphur, averaging 34.5 per cent.

The logs of these churn drill holes, together with the results of the sampling, are given below:

CHURN DRILL HOLE No. 1

Location—Center of Crater No. 1 Claim
Elevation—5379 feet

Date	*From*	*To*	*% S.*	*Remarks*
June				
23	Surface	5		3′ Gravel. Chert
	5	10		Chert. Some gypsum
24	10	15		Chert. 1.5′ conglomerate at 13′
	15	20		Chert
	20	25		Chert
	25	30	1	Chert
25	30	35	6	Chert
	35	40	25	Chert. 2′ ore at 37′
27	40	45	14	Chert. Ore at 44′
	45	50	6	Ore to 47′. Chert
28	50	55	6	Chert, hard
	55	60	13	Chert. Ore 56′ to 61′
	60	65	14	Ore to 61′. Conglomerate
30	65	70	13	Conglomerate
July				
1	70	75	13	Conglomerate with S.
2	75	82.5	14	Conglomerate with S.

Spudded in evening June 21.
Bottomed noon July 2.

(Believe the high grade S showing from 70 to bottom knocked in by top of stem) (ETH)

CHURN DRILL HOLE No. 2

Location—Center of Crater No. 1 Claim
Elevation—5378 feet
Spudded in July 4, 1929
Bottomed at 136′ July 14, 1929 On Section 250 N.

From	*To*	*Feet day*	*% S.*	*Remarks*
0	5	5		Chert
5	10			Chert
10	15			Chert
15	20			Chert
20	25			Chert
25	30	25		Chert
30	35			Chert
35	40			Chert. 38′ to 41′ very hard
40	45	15	17	Chert. Ore at 41′
45	50		31	Ore
50	56		61	Ore
56	60	15	63	Ore
60	65	5	44	Ore (Bitstuck. Fished)
65	70		42	Ore Black S. and gypsum
70	75		42	Ore Black S. and gypsum
75	80	15	35	Ore Black S. and gypsum
80	85	5	32	Ore Black S. and gypsum
85	90		44.5	Ore Black S. and gypsum
90	95		30	Chert, some S.
95	100	15	45	Chert, some S.
100	105	5	30	Chert, some S.
105	110		25	Chert, some S.
110	115		19	Chert, some S.
115	120		25	Chert, some S.
120	125	20	20	Chert, some S.
125	130		15	Conglomerate, some S.
130	135	10		Conglomerate, some S.
135	136	1		Conglomerate, some S.

PACIFIC SULPHUR CORPORATION

CHURN DRILL HOLE No. 3

Location—Center of Crater No. 1 Claim
Elevation—5384 feet
Spudded in July 24, 1929 On Section 250 N.
Bottomed at 260′ August 21, 1929

From	*To*	*Ft. day*	*% S.*	*Remarks*
Surface	20	25		Gravel and semiconsolidated conglomerate
20	25	25		Conglomerate
25	30			Conglomerate
30	35	10		Conglomerate
35	40	5		Conglomerate
40	45			Conglomerate
45	50	10		Conglomerate
50	55			Conglomerate
55	60			Conglomerate
60	65	15		Conglomerate
65	70			Conglomerate
70	75			Conglomerate
75	80			Conglomerate
80	85	20		Conglomerate
85	90			Chert
90	95			Chert
95	100		7	Chert with S.
100	105	20	7	Chert with S.
105	110		8	Chert with S.
110	115	10	5	Chert with S.
115	120		14	Chert with S.
120	125	10	20	Chert with S. (Black S.)
125	130		14	Chert with S. (Black S.)
130	135		2	Chert with S.
135	140		1	Chert with S.
140	145	20	2	Chert with S.
145	150			Chert
150	155	10		Chert
155	160			Chert
160	165			Chert with trace of S.
165	170	15		Chert with trace of S.
170	175			Chert with trace of S.
175	180			Chert with trace of S. Major fault at 176′
180	185	15		Chert with S.
185	190			Chert with S.
190	195		16	Ore
195	200		17	Ore
200	205	20	18	Ore
205	210	5	17	Chert with black S.
210	215		9	Chert with black S.
215	220	10	8	Chert with S.
220	225		8	Chert with S.
225	230		8	Chert with S.
230	235	15		Chert with some S.
235	240			Chert with some S.
240	245	10		Chert with some S. and gypsum
245	250			Chert with some S. and gypsum
250	255			Chert with some S. and gypsum
255	260			Chert with some S. and gypsum

CHURN DRILL HOLE No. 4

Location—N. ½ of Crater No. 1 Claim
Elevation—5357 feet
Spudded in August 23, 1929
Bottomed at 167 ft. August 30, 1929 On Section 500-N.

Date Aug.	*From*	*To*	*Ft. day*	*% S.*	*Remarks*
23	Surface	5			Detritus to 3′. Chert with gypsum
	5	10			Chert with gypsum
	10	15			Chert with gypsum
	15	20			Chert with gypsum
	20	25			Chert with gypsum
	25	30			Chert with gypsum
24	30	35			Chert with gypsum
	35	40			Chert with gypsum
	40	45			Chert with gypsum
	45	50			Chert with gypsum
	50	55	25		Chert with gypsum
25	55	60		8	Chert with gypsum to 57′. Ore at 57′
	60	65		38	Ore
	65	70		53	Ore
	70	75	20	55	Ore
26	75	80		40	Ore
	80	85		27	Ore
	85	90		33	Ore
	90	95	20	26	Chert with S.
27	95	100		25	Chert with S.
	100	105		21	Chert with S.
	105	110	15	20	Chert with S.
28	110	115		21	Chert with S.
	115	120		20	Chert with S.
	120	125		17	Chert with S.
	125	130	20	12	Chert with S.
29	130	135		13	Chert with S.
	135	140		8	Chert with gypsum and some S.
	140	145		7	Chert with gypsum and some S.
	145	150	20	7	Chert with gypsum and some S.
30	150	155			Chert with gypsum and some S.
	155	160			Chert with gypsum and some S.
	160	165			Chert with gypsum and some S.
	165	167	17		Chert with gypsum and some S.

CHURN DRILL HOLE No. 5

Location—N. ½ of Crater No. 1 Claim
Elevation—5360 feet
Spudded in Sept. 1, 1929
Bottomed at 206.5 ft. Sept. 11, 1929 On Section 500-N.

Date	*From*	*To*	*Ft. day*	*% S.*	*Remarks*
Sept.					
1	Surface	5			Detritus
	5	10			Semi-consolidated conglomerate
	10	15	15		Conglomerate
2	15	20			Conglomerate
	20	25			Chert and gypsum
	25	30			Chert and gypsum
	30	35			Chert and gypsum
	35	40			Chert and gypsum
	40	45			Chert and gypsum
	45	50			Chert and gypsum
	50	55	40		Chert and gypsum
3	55	60			Chert and gypsum
	60	65	10		Chert and gypsum
4	65	70			Chert and gypsum
	70	75	10		Chert and gypsum
5	75	80			Chert and gypsum
	80	85			Chert and gypsum
	85	90			Chert and gypsum
	90	95			Chert and gypsum
	95	100	25		Chert and gypsum
6	100	110			Chert and gypsum
	110	115	15		Chert and gypsum
7	115	120			Sulphur, chert and gypsum
	120	125			Sulphur, chert and gypsum
	125	130	15		Chert, gypsum, some sulphur
8	130	135			Chert, gypsum, some sulphur
	135	140	10		Chert, gypsum, some sulphur
9	140	145			Chert, gypsum, some sulphur
	145	150			Chert, gypsum, some sulphur
	150	160	20		Chert, gypsum, some sulphur
10	160	165			Chert, gypsum, some sulphur
	165	170			Chert, gypsum, some sulphur
	170	175			Chert, gypsum, some sulphur
	175	180			Chert, gypsum, trace of sulphur
	180	185			Chert, gypsum, trace of sulphur
	185	190	30		Chert, gypsum, trace of sulphur
11	190	195			Chert and conglomerate at 193′
	195	200			Chert and conglomerate
	200	205			Conglomerate
	205	206.5	16.5		Conglomerate

PACIFIC SULPHUR CORPORATION

CHURN DRILL HOLE No. 6

Location—S. ½, east center of Crater Claim No. 1
Elevation—5370 feet
Spudded in Oct. 5, 1929. Bottomed at 346 ft., Oct. 28, 1929.
Casing—None

Date	*From*	*To*	*Ft. day*	*% S.*	*Remarks*
Oct.					
5	0	15	15		2′ fill. 13′ detritus
6	15	22			Detritus
	22	30	15		Conglomerate, gypsum
7	30	40	10		Conglomerate, gypsum
8	40	60	20		Conglomerate, gypsum
9	60	85	25		Conglomerate, gypsum
10	85	110	25		Chert, gypsum
11	110	135	25		Chert, gypsum
12	135	145			Chert, gypsum
	145	150	15		Chert, gypsum, sulphur
13	150	155	5		Chert, black gypsum, sulphur
16	155	160	5		Chert, black gypsum, sulphur
17	160	170	10		Chert, gypsum, sulphur
18	170	185	15		Chert, gypsum, sulphur
19	185	195			Chert, gypsum, sulphur
	195	205	20		Sulphur, chert, gypsum
20	205	215	10		Sulphur, chert, gypsum
21	215	225	10		Sulphur, chert, gypsum
22	225	238			Sulphur, chert, gypsum
	238	242		18	Sulphur, chert, gypsum
	242	245	20	20	Sulphur, chert, gypsum
23	245	249		32	Sulphur, chert, gypsum
	249	253	8	29	Sulphur, chert, black gypsum
24	253	256		22	Sulphur, chert, black gypsum
	256	259		19	Sulphur, chert, gypsum
	259	262	9	15	Sulphur, chert, black gypsum
25	262	265		18	Sulphur, chert, black gypsum
	265	268		11	Sulphur, chert, black gypsum
	268	277			Chert, traces sulphur
	277	280	18	14	Sulphur, chert, gypsum
26	280	283		19	Sulphur, chert, gypsum
	283	286		17	Sulphur, chert, gypsum
	286	289		13	Sulphur, chert, gypsum
	289	292		7	Sulphur, chert, gypsum
	292	298			Sulphur, chert, gypsum
	298	301	21		Gypsum, some chert, trace sulphur
27	301	322	21		Gypsum, some silica
28	322	330			Gypsum, conglomerate, silica
	330	340			Conglomerate, gypsum
	340	346	24		Conglomerate, bottom

PACIFIC SULPHUR CORPORATION

CHURN DRILL HOLE No. 7

Location—South center of Crater Claim No. 1
Elevation—5385 feet
Spudded in—October 11, 1929. Bottomed at 176 ft., Oct. 29, 1929
Casing—150 ft. 6″ landed at 149′. Pulled 150′. No shoe
Hours drilling—169.5

Date	*From*	*To*	*Ft. day*	*Hrs.*	*% S.*	*Remarks*
Oct.						
11	0	1	1	1.5		Chert, Fe stain
12	1	5	4	9		Chert, Fe stain
13	5	10	5	9		Chert, Fe stain
14	10	25	15	9		Chert, gypsum
15	25	30	5	9		Chert, gypsum
16	30	35	5	9		Chert, gypsum
17	35	45	10	9		Chert, gypsum
18	45	55	10	9		Chert, gypsum
19	55	60	5	9		Chert, gypsum
20	60	70	10	9		Chert, gypsum
21	70	85	15	9		Chert, gypsum
22	85	95	10	9		Chert, gypsum
23	95	105	10	9		Chert, gypsum, sulphur
24	105	115	10	10		Chert, gypsum, sulphur
25	115	125				Chert, gypsum, sulphur
	125	130			35	Sulphur, chert
	130	133	18	10	32	Sulphur, chert
26	133	136			31	Sulphur, chert
	136	139			43	Ore
	139	142			52	Ore
	142	145	12	10	17	Chert, gypsum, sulphur
	145	148			9	Chert, gypsum, sulphur
	148	151			14	Chert, gypsum, sulphur
	151	154	9	9	9	Chert, gypsum, sulphur
28	154	157			39	Ore
	157	160	6	9	27	Conglomerate, chert, gypsum, S.
29	160	163			15	Conglomerate, chert, gypsum, S.
	163	166			20	Conglomerate, chert, gypsum, S.
	166	169			26	Conglomerate, sulphur
	169	172			19	Conglomerate, sulphur
	172	176	16	10	10	Conglomerate, sulphur, bottom
30	Pulling Casing			2		
				169.5		

CHURN DRILL HOLE No. 8

Location—South center of Crater Claim No. 1
Elevation—5380 feet
Spudded in—Oct. 30, 1929. Bottomed at 291′, Dec. 6, 1929

Date	*From*	*To*	*Ft. day*	*% S.*	*Remarks*
Oct.					
30	0	10	10		Gravel
31	10	20			Red chert breccia
	20	30	20		Chert, gypsum
Nov.					
1	30	45	15		Chert, gypsum
22	45	60	15		Chert, gypsum
23	60	80	20		Chert, gypsum
24	80	95			Chert, gypsum, trace S.
	95	105	25		Chert, gypsum, trace S.
25	105	125	20		Chert, gypsum, trace S.
26	125	140	15		Chert, gypsum, trace S.
27	140	150	10		Chert, gypsum, trace S.
28	150	160	10		Chert, gypsum, trace S.
29	160	165	5		Chert, gypsum, S.
30	165	170	5	4	Chert, gypsum, S.
Dec.					
1	170	175		6	Chert, gypsum, S.
	175	178		17	Chert, gypsum, S.
	178	181	11	15	Chert, gypsum, S.
2	181	184		24	Chert, gypsum, S.
	184	187		32	Chert, gypsum, S.
	187	190		36	Chert, gypsum, S.
	190	193		41	Ore
	193	196		45	Ore
	196	199	18	27	Ore
3	199	202		22	Ore
	202	205	6	16	Ore
	205	208		45	Ore
	208	211		47	Ore
	211	214		48	Ore
	214	217		32	Chert, sulphur, gypsum
	217	220		29	Chert, sulphur, gypsum
	220	223		32	Chert, sulphur, gypsum
	223	226	21	29	Chert, sulphur, gypsum
5	226	229		31	Chert, sulphur, gypsum
	229	234		29	Chert, sulphur, gypsum
	234	239		33	Chert, sulphur, gypsum
	239	244		36	Chert, sulphur, gypsum
	244	249		38	Chert, sulphur, gypsum
	249	254		32	Chert, sulphur, gypsum
	254	259		31	Chert, sulphur, gypsum
	259	264		19	Chert, gypsum, sulphur
	264	269	13	17	Chert, gypsum, sulphur
6	269	274		6	Chert, gypsum, conglomerate, sulphur
	274	279		2	Conglomerate, gypsum, sulphur
	279	284		2	Conglomerate, gypsum, sulphur
	284	289			Conglomerate, gypsum, sulphur
	289	291	22		Conglomerate, gypsum, sulphur, bottom

Casing: 198′ of 6″ I.D. landed at 200′ below collar. Pulled 115′. Bottom 4 joints left in hole. (ETH)

Crater No. 5 Claim

Trenches and surface cuts have been dug on this smaller mineralized zone. At the southerly end there is a sulphur ledge striking north-south, dipping 65° west, 3½ ft. wide, 2½ ft. of which is blue-black sulphur instead of the customary resinous yellow variety. An average sample across the ledge gave an assay of 79.4 per cent sulphur. A smaller excavation with 2 ft. of mostly black sulphur ran 83.1 per cent sulphur. This ledge also strikes north-south and dips 80° to the west.

Crater Nos. 3 and 4 Claims

No prospect work has been done on these claims, for the surface material consists of pebble-conglomerate and black limestone. No faults

are discernible, and there is an apparent lack of mineralization on the surface which makes these two claims somewhat unfavorable for prospecting.

Crater Nos. 2 and 6 Claims

As indicated above, the mineralized zone mapped in 1932 on these two claims appeared to have considerable economic possibilities. From 1932 to 1937, various leasers, of whom the Sulphur Diggers, Inc., was the most important, carried on open-cut mining operations on these two claims. Sulphur was developed to a depth of about 40 ft. from the surface, of which 6 to 10 ft. was overburden. From this large pit some 30,000 tons have been mined over a period of five years. The ore averaged 80 to 90 per cent sulphur, and was shipped to Los Angeles. Considerable ore averaging 40 to 50 per cent was left in place or thrown over the dump.

Various methods of treating the lower grade ore were attempted, such as vertical retorts, and steaming sulphur ore in cars in tunnels; but none proved economical, and each in turn was abandoned.

Yellow Sulphur Claims (Figs. 2 and 3)

These claims lie approximately two miles east of the Crater No. 6 claim, over the mountain ridge. They are reached by a trail up a canyon which leads off the main canyon shown on the southeast corner of Fig. 4. Due to their present inaccessibility, they were not thoroughly investigated. A superficial examination showed a well-defined fault running approximately northeast, along which is a good mineralized zone. This faulted zone could be seen to extend for almost a mile. Several pits and trenches exposed some good sulphur.

SAMPLING

The shaft and mine workings were thoroughly sampled, as were many pits and trenches showing a ledge of sulphur of sufficient width.

The shaft was sampled on the average of every 15 feet of depth from the tunnel level to 8 feet below the 100-ft. level, where the ore rests on the coarse pebble-conglomerate. Two or three samples were taken at each point to get the percentage value on each side of the walls of the shaft (Fig. 5).

The tunnel level, 100-ft. level, and 200-ft. level were thoroughly sampled wherever any ore showed. Each sample represented a groove cut along the walls for a distance of five feet. The cuttings were caught on a large canvas, the sample broken and thoroughly mixed, then coned and quartered to an amount that could be easily inserted into a Braun paper sample bag. The sulphur ledges in the pits and trenches were sampled by cutting a groove across their width. These samples were also crushed, coned, and quartered.

Following is a list of all samples taken with the percentage of elementary sulphur of each:

SULPHUR SAMPLES FOR ANALYSIS

	Spec. Grav.	*Sulphur*
Crater Claim No. 1 Pit A	2.02	81.5
B	1.99	98.2
C	2.08	94.8
D	2.28	39.3
E	2.41	37.4
F	2.12	97.9
G	2.07	90.5
H	2.02	98.4
Crater Claim No. 2 Pit I	2.01	87.2
R	2.04	89.1
No. 5 Pit K	2.09	79.4
L	2.13	83.1
No. 6 Pit M	2.06	81.7
N	2.26	18.5
O	2.04	82.6
Crater Mine Shaft No. 1 Sample No. 1	2.06	98.8
No. 2	2.01	94.3
No. 3	1.99	87.8
No. 4	2.06	96.5
No. 5	2.08	65.1
No. 6	2.06	97.1
No. 7	2.10	88.6
No. 8	2.18	49.8
No. 9	2.10	57.7
No. 10	2.08	64.2
Crater Mine Tunnel Sample No. 1	2.51	29.8
No. 2	2.16	92.3
No. 3	2.02	97.7
No. 4	2.33	28.4
No. 5	2.35	26.1
Crater Mine Drift 1-1E Sample No. 1	2.05	85.7
No. 2	2.08	80.0
No. 3	2.22	46.7
No. 4	2.20	71.2
No. 5	2.19	33.9
No. 6	2.01	81.9
Crater Mine Drift 1-1W Sample No. 1	2.21	27.8
No. 2	2.20	23.3
No. 3	2.08	46.6
No. 4	2.14	44.0
No. 5	2.08	64.8
No. 6	2.10	56.1
No. 7	2.27	79.5
Crater Mine Drift 2-2E Sample No. 1	2.02	28.5
No. 2	2.17	37.8
No. 3	2.16	32.5
Crater Mine Drift 2-2W Sample No. 1	2.37	1.2
No. 2	2.31	5.2
No. 3	2.43	6.4
No. 4	2.39	4.2
Crater No. 1 Drift 2-3N Sample No. 1	2.20	35.5
No. 2	2.12	26.2
No. 3	2.11	31.7
No. 4	1.99	28.6
No. 5	1.99	33.1
No. 6	2.06	20.2
No. 7	2.19	37.3
No. 8	2.15	29.0
No. 9	1.92	30.7
No. 10	2.30	19.9
No. 11	2.20	20.7
No. 12	2.11	34.0
No. 13	1.95	29.0
No. 14	1.98	41.3
Crater Claim No. 1 Shaft 2 Sample No. 1	2.00	96.5
No. 2	2.05	92.8
No. 3	2.29	29.4
No. 4	2.17	37.8
Southwest Sulphur Co. 8 ft. Shaft Sample No. 1	2.00	95.2

ESTIMATED TONNAGE

It is always a difficult matter to estimate tonnage of ore in a property where the development work has not been very extensive. In making the following estimate, only the limits of the sulphur orebody as revealed by the drill holes, mine, and pits were included. The balance of the mineralized zone, which probably also carries sulphur, was not figured. The estimate is made on the basis of the distance between

the two extreme sulphur showings, a distance of 923 ft. horizontally. The width of the ore was based on the actual width found in the shaft and the width east and west between drill holes. The depth of the main orebody was taken from the shaft and the various churn drill holes.

If reference be made to the sample and tonnage map (Fig. 6), the method of calculation will be clearly understood. The property was divided into a series of sections lettered A, B, C, D, and E. The total number of square feet in each section was calculated with a planimeter, and the mean of the two adjoining sections multiplied by the distance between them. The total number of cubic feet was multiplied by 130, which is the total number of pounds in a cubic foot of sulphur rock, and the tonnage obtained by dividing by 2,000. The following figures give the estimated tonnage obtained from the various sections:

Section A contains	2802.348 sq. ft.
Section B contains	4290.732 sq. ft.
Section C contains	6783.000 sq. ft.
Section D contains	2647.308 sq. ft.
Section E contains	None

	Tons	*Per cent sulphur*
Total tons in upper orebody	245,581.0	41.0
Estimated tonnage below 200′ level	7,308.0	21.4
Total tonnage in both orebodies	252,890.0	40.3

This estimated total tonnage of approximately 253,000 tons of 40.3 per cent sulphur is believed to be very conservative, and covers only the ore in sight in a small part of an extensive mineralized zone. No doubt considerable additional ore would be developed during mining operations. A very rough estimate of the total tonnage that might be developed in the three various mineralized zones can be made by assuming 250,000 tons of sulphur ore for every 900 feet of mineralization. The results of such a calculation are given below:

Crater No. 5 orebody	360,000 tons
Crater No. 1 orebody	640,000 tons
Crater Nos. 2 and 6 orebodies	750,000 tons
Total possible ore reserves as of 1932	1,350,000 tons

Later work on Claims Nos. 2 and 6 indicate that probably another million tons can be developed on them. It is believed that there are approximately 2,500,000 tons of sulphur available on all the six Crater claims.

If such a tonnage of 40 per cent sulphur ore is obtainable at the mine, it seems reasonable to suppose that it would be more economical to bring in fuel and extract the sulphur from the ore, freighting 99.5 per cent crude sulphur to Los Angeles, than to ship out for reduction waste in the amount of 60 per cent.

ECONOMIC POSSIBILITIES

There is no doubt that the Crater area of Inyo County has considerable economic possibilities, providing sufficient capital is available to place the properties on an efficient operating basis. To date, mining has been limited to high-grade ore which could be extracted with the least trouble and expense. The largest tonnage, running into several million tons, consists of probably 40 per cent sulphur ore. A method

either to reduce this 40 per cent ore to 99 per cent pure sulphur, or to concentrate it by milling operations must be devised to make this an economic project. Milling or metallurgical tests to devise the best process on several carloads of run of the mine sulphur ore should be made by some reputable concern in that business.

The great drawback to reduction work at the mine itself is the lack of water. It is believed that water is available on the floor of Eureka Valley at some point opposite the entrance to the sulphur deposit. The author recollects being told by a water well-drilling operator that water had been found in that immediate locality at a depth of 40 feet. If such is the case, and it could be proven at a small expense, a reduction plant should be located in Eureka Valley four or five miles from the sulphur deposit. The cost of hauling sulphur and waste rock four or five miles should be small, as the loaded trucks would coast downhill and make the up-grade return trip empty.

The present long haul of 68 miles from Zurich to Crater via Oasis should be eliminated because of the cost of hauling over three steep grades. It is feasible to build a road in a westerly direction across Eureka Valley from the sulphur deposit to connect via Marble Canyon with the Salinas Valley road to Zurich.

The open-cut pit on Crater No. 2 has revealed the existence of a large body of ore underlying the mineralized zone outlined in Fig. 4. It is reasonable to suppose that this orebody extends for a considerable distance at a shallow depth, lending itself to further open-cut mining. Underground mining, as it has been carried on by means of laterals from the open cut, should be discontinued because of the excessive cost.

The mine shaft with its compact linear orebody offers good economic possibilities. Topographically, Crater No. 1 claim adapts itself readily to open-cut mining. The bottom of the ore in the shaft is 108 ft. below the collar of the shaft. By starting operations at a point 100′+ below the collar of the shaft in the draw north of the shaft, open-cut mining could be carried on progressively to the south on the orebody. A face of sulphur ore up to a vertical height of 100′± would be available as operations approached the shaft.

Inyo County has a valuable nonmetallic deposit in the Crater sulphur mine, which should be efficiently exploited for the benefit of both the county and the owners.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

BIENNIAL REPORT OF THE STATE MINERALOGIST

HON. GEORGE D. NORDENHOLT, *Director,*
Department of Natural Resources,
Sacramento, California.

SIR: Herein I have the honor to present the biennial report of the State Mineralogist as required by law (Stats. 1913, Chap. 679) for transmittal to His Excellency, Governor Frank F. Merriam, covering the work and activities of the Division of Mines of the Department of Natural Resources, for the period July 1, 1936, to June 30, 1938.

General Summary.

Looking back over the past two years, the staff of the Division of Mines can view with genuine satisfaction the amount and quality of the work accomplished in behalf of the mineral industries of California. This state is an extensive empire and has widespread and diversified resources of minerals not excelled by any other equal area on the face of the planet. It is a big task for the small staff of the division to adequately cover this large assignment and keep up-to-date on the economic developments in all of the various mineral industries and areas within our borders. That we have accomplished much, commensurate with the means available, is testified to in letters and oral commendations from many identified with our mineral industries, and is evidence of the loyalty and sincere interest of the staff in their field of endeavor.

Activity has continued unabated in gold mining in California; likewise in the oil fields. In the latter, geophysical prospecting followed by drilling has resulted in the discovery of several new fields, particularly in the southern end of the San Joaquin Valley area. Building and structural materials as well as other nonmetallic industrial minerals and salines have varied, some being active while others have fluctuated considerably.

The mineral technologist in the laboratory of the division headquarters office has been kept busy, with his assistant, in indentifying and classifiying samples sent in from every section of the state. Our file shows reports made on 13,190 samples during this two-year period, an increase of 19 per cent over the preceding two years. While a considerable proportion of these samples received prove not to be of apparently commercial value, yet the value of the service rendered has a greater significance than that fact would indicate on its surface. Negative information is frequently as important as positive, as it tells the prospector or other sender whether expenditure of time and money in further digging is justified.

Successive renewals have been obtained of the Federal Works Progress Administration projects in the San Francisco headquarters

office of this division, also for the mining-claim mapping and records projects in the Sacramento and Los Angeles offices. The mining-claim projects in the county recorders' offices were concluded and the records concentrated in those two district offices of the division. The clerical, cataloguing, indexing and map-making project in the San Francisco office was renewed each year and has been expanded to a total personnel of 60 persons. Through the assistance obtained in these WPA projects we were able to complete the preparation ready for the printer

High-grade gold specimens and nuggets, exhibited by the Division of Mines, at the State Fair.

of three pieces of work in particular: 1. The Geologic Map of California by Olaf P. Jenkins, Chief Geologist; lithographed in eight colors and showing 80 segregated formational units. 2. Bulletin 113, on the "Minerals of California," by Adolf Pabst, Associate Professor of Mineralogy, University of California. 3. Bulletin 115, on the "Bibliography of California Geology and Mineral Resources, 1931 to 1936 inclusive," by Dr. Solon Shedd, librarian of Branner Memorial Library (Geological) at Stanford University; and which supplements the master bibliography, our Bulletin 104, issued in 1932 covering all publications on these subjects from the earliest known writings up to the end of 1930.

Each year at the State Fair at Sacramento, the Division of Mines has placed an exhibit with members of the staff in attendance, showing in visual evidence some measure of the great value and diversity of California's mineral resources. Included each time has been an electric-lighted safe with gold, platinum, and gem specimens.

Ore Buyers Inspector's Summary.

September, 1936, in cooperation with the United States Secret Service, nine men and one woman were arrested in Nevada County for violation of the Gold Reserve Act. The total amount of gold sold in these cases was $300,000. Cases against two of these men involved in this case were dismissed for lack of evidence; two others were aquitted before the Federal Court, and the other six were convicted. They received sentences ranging from 18 months to 5 years.

December, 1936, three men were arrested and charged with conspiracy to violate the Gold Act; later the three were convicted in Federal court and received sentences of 8 months in the county jail. The amount of gold involved in this case was $8,000.

March, 1937, four men from Los Angeles were arrested and later two of them were convicted and fined $2,500 each. Later two more men were arrested in Mariposa County and charged with falsifying affidavits to the United States Mint and were sentenced to 2 years in Federal penitentiary.

August, 1937, three men were arrested in Sierra County, one of whom was charged with grand theft and the other two with petty theft. The man charged with grand theft was given 6 months in the county jail, and the other two charged with petty theft were sentenced to 60 days each in the county jail.

February, 1938, John Bongard, the Ore Buyer's Inspector of this Division, in cooperation with the authorities of El Dorado County, arrested eight men for grand theft and ten for petty theft. Six of those charged with grand theft pleaded guilty and were sentenced to 90 days in the county jail and 5 years probation. Two elected to stand trial and were convicted; they were sentenced from 1 to 14 years in San Quentin. The 10 charged with petty theft pleaded guilty and were sentenced to 90 days in the county jail. The total recovery of around $15,000 was netted in high-grade rock and currency.

The following number of receipt books were issued to licensees: 1936, 796; 1937, 824; Total, 1620.

The following number of licenses were issued: Limited—1936, 98; 1937, 81; Total 179. Unlimited—1936, 111; 1937, 109; Total, 220.

Geologic Branch.

The most notable achievement of the Geologic Branch has been the final publication of the Geologic Map of California, scale 1:500,000, colored, in 6 sheets. Though this map is not a full 100 per cent "complete," it was considered best to leave the geology blank on those areas on which data were not available comparable in quality and accuracy to the balance of the state. These "white spots" should offer an incentive to geologists to work and to the holders of our purse strings to furnish funds to *complete* the job thus far so well done. The Geologic Branch has also made steady progress in cooperation with outside institutions and in the compilation of published data through the assistance of WPA projects. A considerable number of reports and maps have been published during the biennium (as indicated below) and several manuscripts are ready to be printed; others are in the process of preparation. In order to complete unfinished reports, the Geologic Branch should be supplied with a special fund for necessary expenses. In order to make these reports available to the public, a larger allotment of money is needed for printing.

Until very recently, only one person has been regularly employed on the staff, the Chief Geologist. Now he is supplied with one technical assistant, a geological clerk. In a short while, a geological draftsman is to be added to the staff. There is much need for a stenographer in this work, and it is hoped that sometime in the future at least one assistant field geologist may be employed to carry on special investigations of the geology of economic mineral deposits.

REPORTS PREPARED UNDER THE DIRECTION OF THE GEOLOGIC BRANCH

(Including publications of this biennium, reports in press, and reports ready for the printer)

1937

Source Data of the Geologic Map of California, January, 1937—by Olaf P. Jenkins (Chief Geologist).

The Geology of Quicksilver Ore Deposits—by C. N. Schuette (Consulting Mining Engineer and Geologist).

Geology and Mineral Deposits of the Western San Gabriel Mountains, Los Angeles County—by Gorden B. Oakeshott (University of Southern California).

Paleozoic Section in the Nopah and Resting Springs Mountains, Inyo County, California—by John C. Hazzard (University of Southern California).

1938

Geologic Map of California, in six sheets, scale 1:500,000—by Olaf P. Jenkins (Chief Geologist).

Minerals of California (Bull. 113)—by Adolf Pabst (University of California).

Bibliography of the Geology and Mineral Resources of California for the years 1931 to 1936, inclusive (Bull. 115)—by Solon Shedd (Stanford University).

Doing Something About Earthquakes—by R. R. Lukens (U. S. Coast and Geodetic Survey).

Gold and Petroleum in California—by Waldemar Lindgren (Massachusetts Institute of Technology).

Geology of the Central Santa Monica Mountains, Los Angeles County—by E. K. Soper (University of California at Los Angeles).

Submarine Canyons off the Coast of California—by Francis P. Shepard (University of Illinois and Scripps Institute of Oceanography).

Strategic Minerals in California—by Charles W. Merrill (U. S. Bureau of Mines).

Geology and Ore Deposits of the Darwin Silver-Lead Mining District, Inyo County, California—by Vincent C. Kelley.

Geology of the Newberry and Ord Mountains—by Dion Gardner.

Reports Now in Preparation, Under Direction of Geologic Branch

Geologic Formations and Economic Development of the California Oil and Gas Fields—by many contributors, prepared under direction of Olaf P. Jenkins (Chief Geologist).

A Series of Economic Mineral Maps of California—by the Geologic Branch.

Geology and Mining of the Borate Deposits of the Kramer District, San Bernardino County—by Hoyt S. Gale (Consulting Geologist).

Geology and Mineral Deposits of the Duncan Mills and Sebastopol Quadrangles—by F. A. Johnson (University of California).

Geology of the Shasta Copper District—by G. F. Seager (Yale University).

Geology and Ore Deposits of the Bodie Mining District, Mono County—by Francis Frederick (University of California).

Geology of the Amboy Quadrangle, San Bernardino County—by John C. Hazzard (University of Southern California).

Geology of San Nicolas and Santa Barbara Islands—by Luis E. Kemnitzer (California Institute of Technology).

Tertiary Geology of a Part of Northern California—by R. Dana Russell.

Quicksilver Resources of California—by Alfred Ransome.

PUBLICATIONS

Publications issued July 1, 1936, to June 30, 1938:

July and October chapters of State Mineralogist's Report XXXII, 1936.

Among the more important subjects included are:

Mines and Mineral Resources of Calaveras County.
Mineral Resources of Lassen County.
Mineral Resources of Modoc County.
Mechanics of the Lone Mountain Landslides, San Francisco.

Special articles on:

Placer Mining in California by Power Shovel.
Assessment Work on Mining Claims within Withdrawn Areas.
Joshua Tree National Monument.
Cost of Producing Quicksilver at a California Mine in 1931-1932.
The Age of Mineral Utilization.
Biennial Report of the State Mineralogist.
Properties and Industrial Applications of Opaline Silica.

State Mineralogist's Report XXXIII, 1937. Among the more important subjects included are:

Source Data of the Geologic Map of California, January, 1937.
The Geology of Quicksilver Ore Deposits.
Mineral Resources of Plumas County, with Geologic Map.
Mineral Resources of Los Angeles County, with map.
Geology and Mineral Deposits of the Western San Gabriel Mountains, Los Angeles County, with Geologic Map.
Mineral Resources of the Resting Springs Region, Inyo County.
Paleozoic Section in the Nopah and Resting Springs Mountains, Inyo County.

Special articles on:

Prospecting for Lode Gold.
New Placer Mining Debris Law.
Native Arsenic from Grass Valley, California.

January and April, 1938, chapters of State Mineralogist's Report XXXIV. Among the more important subjects included are:

Mineral Development and Mining Activity in Southern California during the year 1937.
Doing Something About Earthquakes.
Gold and Petroleum in California.
Gold Dredging in Shasta, Siskiyou and Trinity Counties.
Geology of the Central Santa Monica Mountains, Los Angeles County.

Special articles on:

Gem Minerals of California; and Lapidary Art.
Marketing Mica.

Bulletin 112. California Mineral Production and Directory of Mineral Producers for 1935, by Henry H. Symons, 205 pages, 7 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year 1935.

Bulletin 113. Minerals of California, by Adolf Pabst, Associate Professor of Mineralogy, University of California, 344 pages, 1 illustration. Lists all known minerals found in California, and describes their characteristics and occurrences.

Bulletin 114. California Mineral Production and Directory of Mineral Producers for 1936, by Henry H. Symons, 199 pages, 5 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year 1936.

Bulletin 115. Bibliography of the Geology and Mineral Resources of California, for the years 1931 to 1936 inclusive, by Solon Shedd, librarian of the Branner Memorial (Geological) Library, Stanford University. This bulletin supplements Bulletin 104, the "master bibliography" covering the same subjects from the earliest known writings on California to the end of 1930.

Conclusion

In conclusion we can but reiterate what we have said in previous reports: that California is outstanding in the diversity and economic values and potentialities of her mineral resources; and as the only state agency fostering the economic development of these resources, the Division of Mines deserves generous support for the continued maintenance of its services to the public and these industries.

Respectfully submitted.

WALTER W. BRADLEY,
State Mineralogist.

October 10, 1938.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel

There have been no changes of personnel in the Division of Mines to be noted in the past three months.

New Publication

Geologic Map of California. In six sections each 32 inches by 42 inches, each overlapping and carrying separate legend. When assembled as a wall map, it is 6½ ft. by 7½ ft. By combinations of colors, shades and rulings, 80 geologic formations are distinguished. Contains also various charts showing source data, index to topographic maps, index to the township and range system, dimensions and areas of the state and its counties, a rainfall map, geologic time chart, geomorphic map showing submarine contours, mineral chart, and master legend. Highways and roads are shown accurately.

Commercial Mineral Notes (Nos. 184-186 incl.) August, September, October, 1938, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to four pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

Henry H. Symons, Statistician and Curator

STATISTICS

The complete, detailed annual report on the mineral production of California for 1937, with a directory of producers, will be available, as Bulletin No. 116 of the State Division of Mines. The 1937 mineral output was valued at $361,515,951. See July, 1937, issue of California Journal of Mines and Geology.

SOURCES OF GOLD PRODUCED IN CALIFORNIA FROM 1848 TO 1937

Gold came from California as early as 1841 [1] and possibly as early as 1820 [2], having been mined from stream gravels near Los Angeles by the Indians and shipped to the Philadelphia Mint by the way of Mexico. The padres and the rancheros discouraged the quest for gold, so the early small production went practically unnoticed.

The discovery of gold by James W. Marshall in the tail-race of Sutter's sawmill at Colma on the American River, on January 24, 1848, brought about the gold rush which made California a commonwealth of the first rank in a very short period.

The data on the various methods of placer mining and types of ore from which the lode gold was derived, were compiled by James M. Hill [3] in 1928 who gives the placer and lode values of gold in ten-year periods also from 1900 the annual value by sources as well as lode and placer up to and including 1926. The Division of Mines has compiled these data to include 1937 by taking available information from the annual numbers of the U. S. Bureau of Mines, Mineral Resources (1927 to 1931), and U. S. Bureau of Mines Mineral Year Book (1932 to 1938). To Mr. Hill's table such changes and additions were made to give a more detailed break-down of sources as far back as possible.

The first gold produced was by small-scale hand methods of placering where the miner used sluice boxes, rockers, long toms and pans. In 1852 hydraulic mining was started near Nevada City and continued to flourish until the Sawyer decision in 1884, since which this method has been limited.

Drift mining on the ancient buried-river channels started at Forest Hill, Placer County, in 1852 and was an important source of placer gold from 1866 to 1900.

[1] Hittell, T. H., History of California, Vol. II, p. 312, 1885.

[2] Bancroft, H. H., History of California, Vol. II, p. 417, 1886.

[3] Hill, James M., Historical Summary of Gold, Silver, Copper, Lead and Lime Produced in California, 1848 to 1926, U. S. Bureau of Mines Economic Paper 3, 1928.

Dredge production started on the Feather River in 1898 and by 1903 was the chief source of placer gold and has continued so to date.

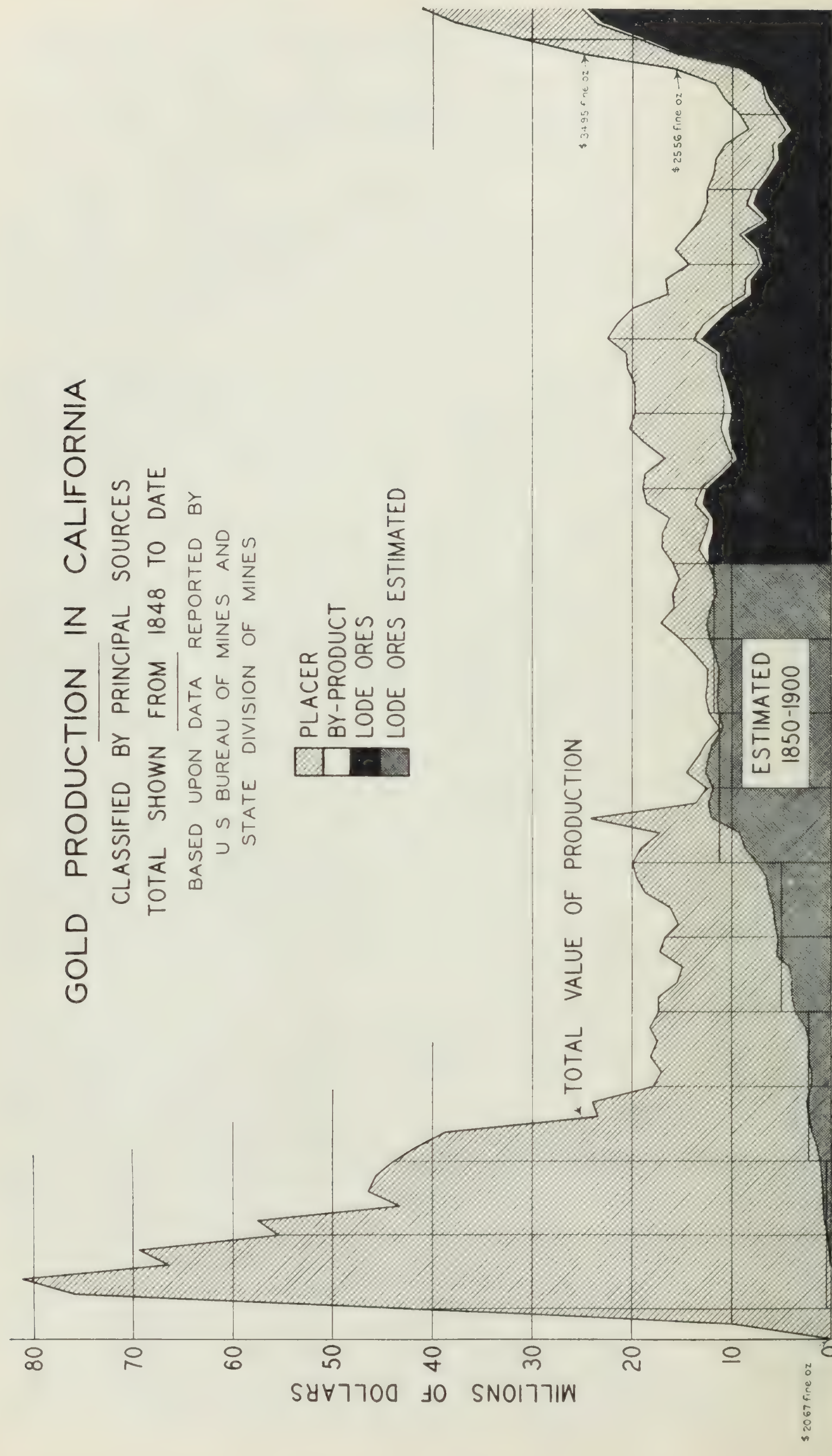
In 1933 when the ounce value of gold was increased it became profitable to work with dragline dredges and power shovels gravel properties which were too small for the standard bucket-line dredges. By 1935 these were an important source of the precious metal.

The lode or deep mines began operation in or about 1851 and by 1885 were the chief source of Californian gold. Prior to 1900 there was no definite segregation of placer and lode-gold statistics but a fairly accurate estimate can be made. An interesting fact is, that the 1937 lode-gold output with the largest lode value in the history of the State undoubtedly has also the largest annual output in ounces from the veins.

The accompanying chart was prepared by the Division of Mines from the annual gold figures and contains many points of interest. In 1852 the high-record annual gold output was achieved by hand-mining methods by the hundreds of thousands of men who rushed to the new El Dorado to make their fortune, also the richest surface placers were being skimmed. From this on till 1880 it was a new industry in a new country, finding its own level through men who came out to mine, but among whom many found other methods of making a living, more profitable or more to their liking. During this same period, also, others were attracted to new gold strikes in different parts of the world. From 1852 to 1885 as the amount of gold coming from the placers decreased the lodes were being developed and were increasing in output. In 1884 the decision by Judge Sawyer brought hydraulic mining to a standstill.

From 1885 on, the trend of business throughout the United States had a direct bearing on the mining of gold in California. During periods of financial prosperity the gold output was down, while during periods of financial depression the gold output increased. From 1888 to 1892 the gold output was down, but business in the United States as a whole was good, owing to the large-scale railroad construction throughout the country. In 1893 the panic increased the demand for gold, until the silver campaign depression of 1897. In 1893, the Caminetti act stimulated placer mining with the hope of the restoration of hydraulic mining.

The first gold dredge made its appearance on the Feather River in 1898 and proved a success, stimulating placer operations. The general merger of business in 1903 increased business in general and gold production dropped off. The panic of 1904 put gold on the upward trend, while the prosperity of 1905 to 1907 brought about a gradual decline in output. The panic of 1907-1909 and the war depression of 1914 all brought increased gold yield. The war prosperity 1915-1918 showed a gradual lessening in gold mining. The post-war depression of 1921 changed the trend for a year while the post-war prosperity and reconstruction period 1924 to 1927 and market boom of 1929 caused the interest in gold to lessen to such a point that the 1929 output was the smallest in the history of the State since 1848. The depression of 1929 stimulated the demand for gold which was further augmented by the increased prices from August 29, 1933, and the Gold Reserve Act of 1934 in effect on January 30, 1934, placing a value of $35 a fine ounce



GOLD PRODUCTION IN CALIFORNIA
CLASSIFIED BY PRINCIPAL SOURCES
TOTAL SHOWN FROM 1848 TO DATE
BASED UPON DATA REPORTED BY
U S BUREAU OF MINES AND
STATE DIVISION OF MINES
PLACER
BY-PRODUCT
LODE ORES
LODE ORES ESTIMATED
TOTAL VALUE OF PRODUCTION
ESTIMATED
1850-1900
MILLIONS OF DOLLARS
0
10
20
30
40
50
60
70
80
1850
1860
1870
1880
1890
1900
1910
1920
1930
$20.67 fine oz
$25.56 fine oz
$34.95 fine oz

on gold. The above act has also made it possible to work low-grade deposits at a profit which at no time previously would pay, at $20.67 per ounce.

The 1937 gold output was the largest in any year from 1861 in value, and 1862 in ounces, with the exception of 1883.

VALUE OF GOLD PRODUCED IN CALIFORNIA, 1848 TO 1937 FROM VARIOUS SOURCES

Period	Placer				
	Dredge	Hydraulic	Surface sluice	Drift	Total
1848-1850					$51 669,767
1858-1860					581,561,868
1861-1870					211,388,439
1871-1880					120,910,077
1881-1890					37,881,328
1891-1900	[6]$426,118				29,416,001
1901	471,762	[8]$1,698,720	[8]$719,078	[8]$1,061,489	3,951,049
1902	867,665	[9]1,256,222	[9]1,234,554	[9]889,161	4,247,602
1903	1,475,749	872,812	798,521	905,679	4,052,761
1904	2,187,038	1,028,183	836,115	933,954	4,985,290
1905	3,276,141	975,140	825,555	815,240	5,892,076
1906	5,098,359	1,054,172	617,577	605,817	7,375,925
1907	5,065,437	909,011	302,864	563,383	6,840,695
1908	6,536,189	743,797	560,656	390,545	8,231,187
1909	7,382,950	605,608	376,078	739,797	9,104,433
1910	7,550,254	635,498	186,114	516,929	8,888,795
1901-1910	39,911,544	9,779,163	6,457,112	7,421,994	63,569,813
1911	7,666,461	675,486	164,680	479,900	8,896,527
1912	7,429,955	689,682	138,034	387,992	8,645,663
1913	8,090,294	329,300	224,045	192,538	8,836,177
1914	7,783,394	702,884	264,623	329,948	9,080,849
1915	7,796,465	420,770	118,427	272,955	8,608,617
1916	7,769,227	390,015	165,118	251,297	8,575,657
1917	8,313,527	267,103	126,641	366,759	9,074,030
1819	7,431,927	213,229	85,203	108,420	7,838,779
1919	7,716,919	184,832	45,984	85,341	8,033,076
1920	6,900,366	66,233	31,089	62,925	7,060,613
1911-1920	76,898,535	3,939,534	1,363,844	2,538,075	84,739,988
1921	7,756,787	162,808	107,818	127,411	8,154,824
1922	4,999,215	158,275	89,739	252,626	5,499,855
1923	6,065,735	111,828	160,249	184,771	6,522,583
1924	4,305,521	60,195	124,088	98,568	4,588,372
1925	4,750,842	175,345	103,434	66,523	5,096,144
1926	4,950,545	69,139	97,483	111,236	5,228,403
1927	5,461,929	141,929	120,832	112,623	5,837,313
1928	4,430,913	153,386	91,512	174,818	4,850,629
1929	3,589,259	84,668	59,732	136,948	3,870,607
1930	3,451,801	62,615	89,403	151,324	3,755,143
1921-1930	49,762,547	1,283,733	1,099,069	1,258,524	53,403,973
1931	3,619,355	111,199	62,556	227,636	4,020,746
1932	3,903,481	205,880	122,876	533,238	4,765,475

Period	Placer							
	Surface placers						Underground placers drift	Tota
	Connected-bucket dredges	Drag line dredges	Non-floating[14] washing plants	Hydraulic	Small-scale wet	Hand method dry[14]		
1933[11]	$5,155,716	$1,924	$40,442	$114,890	$928,098	$5,737	$434,036	$6,680,843
1934[12]	6,772,380	121,138	203,810	324,397	1,694,919	6,426	454,098	9,577,168
1935[13]	8,274,130	776,701	416,240	476,809	1,545,153	4,494	599,883	12,093,410
1936	9,671,347	1,748,864	422,079	268,450	1,369,620	11,827	837,618	14,329,805
1937	11,303,635	3,294,970	597,765	161,980	896,420	17,010	258,930	16,530,710
1931-1937	48,700,044	5,943,597	1,680,336	1,663,605	6,619,642	45,494	3,345,439	67,998,257
Grand totals	$215,698,788	$5,943,597	$1,680,336	$16,666,035	$15,539,667	$45,494	$14,564,032	$1,302,539,511

[1] Estimated as 100 per cent from placer mines.
[2] Estimated as 1 per cent from gold-lode mines and 99 per cent from placer mines.
[3] Estimated as 10 per cent from gold-lode mines and 90 per cent from placer mines.
[4] Estimated as 30 per cent from gold-lode mines and 70 per cent from placer mines.
[5] Estimated as 75 per cent from gold-lode mines and 25 per cent from placer mines.

VALUE OF GOLD PRODUCED IN CALIFORNIA, 1848 TO 1937 FROM VARIOUS SOURCES—Continued

Period	Lode					Total value
	Gold ore	Copper ore	Lead ore	Zinc ore	Total	
1848-1850						[1]$51,669,767
1851-1860					$5,874,362	[2]587,436,230
1861-1870					23,487,604	[3]234,876,043
1871-1880					51,818,604	[4]172,728,681
1881-1890					113,643,986	[5]151,525,314
1891-1900					117,664,005	[7]147,080,006
1901	$12,499,743	$421,385	$116,867		13,037,995	16,989,044
1902	12,295,261	361,951	5,506		12,662,718	16,910,320
1903	[10]11,973,291	[10]272,801	[10]1,800		12,247,892	16,300,653
1904	13,136,758	511,108	520		13,648,386	18,633,676
1905	12,772,219	224,650	9,600		13,006,469	18,898,545
1906	11,036,018	318,489	1,020	$1,000	11,356,527	18,732,452
1907	9,532,771	344,421	9,504	537	9,887,233	16,727,928
1908	10,050,853	473,092	6,427		10,530,372	18,761,559
1909	10,433,400	691,062	8,975		11,133,437	20,237,870
1910	10,143,780	658,288	24,577		10,826,645	19,715,440
1901-1910	113,874,094	4,277,247	184,796	1,537	118,337,674	181,907,487
1911	10,317,794	427,789	6,798		10,752,381	19,738,908
1912	10,771,759	293,946	1,717	393	11,067,815	19,713,478
1913	11,222,566	320,939	27,276		11,570,781	20,406,958
1914	11,200,323	343,776	28,548		11,572,647	20,653,496
1915	13,315,559	491,940	23,555	2,625	13,833,679	22,442,296
1916	11,876,291	922,876	35,504	413	12,835,084	21,410,741
1917	10,244,720	669,809	98,945		11,013,474	20,087,504
1918	8,287,599	319,701	82,455	419	8,690,174	16,528,953
1919	8,499,014	126,866	36,887	112	8,662,879	16,695,955
1920	7,158,329	38,459	53,642		7,250,430	14,311,043
1911-1920	102,893,954	3,956,101	395,327	3,962	107,249,344	191,989,332

Period	Lode							Total placer and lode value
	Gold ore	Gold-silver[15] ore	Silver ore[16]	Copper ore	Lead ore	Zinc ore	Totals	
1921	$7,317,692		$184,824	$29,747	$16,681	$1,054	$7,549,998	$15,704,822
1922	8,905,622		105,280	118,632	30,012	10,945	9,170,491	14,670,346
1923	6,438,818		206,284	177,129	34,199		6,856,430	13,379,013
1924	7,933,780		170,661	436,786	16,442	4,134	8,561,803	13,150,175
1925	7,429,269		146,227	342,834	47,083	3,773	7,969,186	13,065,330
1926	6,334,909		84,125	233,612	22,636	19,796	6,695,078	11,923,481
1927	5,411,442		64,806	342,259	8,259	6,939	5,833,705	11,671,018
1928	5,515,916		67,164	345,751	5,855		5,934,686	10,785,315
1929	4,187,591		46,464	414,384	7,657		4,656,096	8,526,703
1930	5,123,653		76,868	485,236	10,262		5,696,019	9,451,162
1921-1930	64,598,692		1,152,703	2,926,370	199,086	46,641	68,923,492	112,237,465
1931	6,450,853	$14,766	17,943	281,291	28,563		6,793,416	10,814,162
1932	6,901,890	227	34,334	32,275	31,525		7,000,251	11,765,726
1933	8,931,465	33,773	93	29,495	6,065	1,341	9,002,232	15,685,075
1934	15,423,796	88,171	2,575	1,269	38,305		15,554,116	25,131,284
1935	18,877,312	634	84,166	95,478	14,033	17	19,071,640	31,165,050
1936	22,842,470	33,985	42,735	449,015	12,075	385	23,380,665	37,710,470
1937	23,401,315	546,000	81,305	539,105	11,445	350	24,579,520	41,110,230
1931-1937	102,829,101	717,556	263,151	1,427,928	142,011	2,093	105,381,840	173,381,997
Totals	$384,195,841	$717,556	$1,415,854	$12,587,646	$921,220	$54,232	$712,380,811	$2,014,920,222

[6] Dredge production first recorded in 1898, $18,887; 1899, $206,302; 1900, $200,929. See U. S. Geological Survey Mineral Resources, Pt. 1, 1914, p. 357, for table to date. Note previous tables gave no production for 1898.
[7] Estimated as 80 per cent from gold-lode mines and 20 per cent from placer mines.
[8] Estimated distribution from information in Annual Report of Director of Mint, 1901, p. 90.
[9] Estimated distribution from information in Annual Report of Director of Mint, 1902, p. 76.
[10] From U. S. Geological Survey tabulation sheets.
[11] Value calculated at an average weighted price of $25.56 a fine ounce; previously $20.6718.
[12] Value calculated at an average weighted price of $34.95 a fine ounce.
[13] Value calculated at $35 a fine ounce.
[14] Prior to 1933 was included with small-scale hand methods wet.
[15] Prior to 1931 under gold ores.
[16] Prior to 1921 under gold ores.

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20881 DAHLLITE, a carbonated calcium phosphate.
From Manhattan, Nevada.
Donor: W. C. Eyles. August, 1938.

20882 VASHEGYITE (green), a hydrous aluminum phosphate; with LAUBANITE (white), a hydrous calcium-aluminum silicate.
From Manhattan, Nevada.
Donor: W. C. Eyles. August, 1938.

20883 CINNABAR (HgS), mercury sulphide—a piece of float.
From near Cambria, San Luis Obispo County, California.
Donor: M. D. Gaines. August, 1938.

20884 PHARMACOLITE, an acid, hydrous calcium arsenate—$HCaAsO_4.2H_2O$.
From White Caps Mine, Manhattan, Nevada.
Donor: Hatfield Goudey. August, 1938.

20885 TOURMALINE, a complex silicate of boron and aluminum, $HAl_3(B.OH)_2Si_4O_{19}$.
From Lucky Strike Mine, four miles due south of Engle Mine—Sec. 28, T. 29 N., R. 11 E.—Plumas County, California.
Donor: G. L. Holmes. September, 1938.

20886 CHALCANTHITE, hydrous cupric sulphate, $CuSO_4.5H_2O$.
From True Friend Mining Claim, Masonic Mining District, Mono County, California.
Donor: Byron A. Krebs. September, 1938.

20887 WULFENITE, $PbMoO_4$. Lead molybdate crystals in cluster.
From Miess, Yugoslavia. Exchange. October, 1938.

20888 FLUORITE, CaF_2—Calcium Fluoride.
From Afton, San Bernardino County, California.
Donor: Morio Kitagaki. October, 1938.

20889 GYPSUM, $CaSO_4.2H_2O$.
From Santa Monica Cliffs, Los Angeles County, California.
Donor: E. F. Montgomery. October, 1938.

20890 QUARTZ, SiO_2—bull quartz showing zone structure of crystals.
From Shingle Springs, El Dorado County, California.
Donor: V. E. Perish. October, 1938.

20891 ZIRCON, sand first mined commercially in California.
From Kaufield Gold Dredge, Lincoln, Placer County, California.
Laboratory. October, 1938.

20892 CORAL, $CaCO_3$—recent.
From Fiji Islands.
Donor: Walter W. Bradley. October, 1938.

LABORATORY

GEORGE L. GARY, Acting Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, "Minerals of California," by Adolph Pabst, was published this year by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

No. 3—Chalcanthite, a hydrous cupric sulphate from the True Friend mining claim in the Masonic mining district, Mono County.

No. 4—Basanite, silicon dioxide, a velvet black siliceous stone or flinty jasper, used on account of its hardness and black color for trying the purity of the precious metals, from the beach, San Francisco County.

No. 5—Garnierite, a hydrous magnesium and nickel silicate from the Aurora mine, near the New Idria mine, San Benito County.

No. 6—Titanite. A few small envelope shaped crystals of titanite in a pegmatite rock from the Mountain district, eastern Madera County.

No. 7—Psilomelane, a manganese oxide associated with pink rhodonite, a manganese silicate from 12 miles southwest of Soledad and about 4 miles west of Paraiso Springs, Monterey County.

No. 8—Rhodonite, a manganese silicate associated with psilomelane, a manganese oxide from 12 miles southwest of Soledad and about 4 miles west of Paraiso Springs, Monterey County.

No. 9—Satin-spar, a variety of gypsum that is fine—fibrous, with pearly opalescence, from Salinas, Monterey County.

No. 10—Covellite, an indigo-blue cupric sulphide associated with chalcoyprite, from near Groveland, Tuolumne County.

No. 11—Montroydite, mercuric oxide with cinnabar from the Red Elephant mine, near Lower Lake, Lake County.

No. 12—Montroydite, mercuric oxide with native quicksilver and cinnabar, from the Esperanza mine on Sulphur Creek, east of Cloverdale, Sonoma County.

No. 13—Cerusite, a lead carbonate as a heavy yellow concentrate in sands from near Healdsburg, Sonoma County.

LIBRARY

J. C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE ESPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Professional Papers:

189 A Species and Genera of Tertiary Noetinae.
189 C Pliocene Diatoms from the Kettleman Hills, Calif.
189 E The Force Required to Move Particles on a Stream Bed.
190 Lower Pliocene Mollusks and Echinoids from the Los Angeles Basin, California.

Technical Papers:

582 Methods for the Detection and Determination of Carbon Monoxide.
585 Flotation for Recovery of Scheelite from Slimed Material.
586 Notes on the Sampling and Analysis of Coal.

Water Supply Papers:

810 Surface Water Supply of the U. S. Part 10—The Great Basin.
820 Dwight of 1938. With Discussion on the Significance of Drought in Relation to Climate.

830 Surface Water Supply of the U. S., 1937. Part 10. The Great Basin, Calif., Idaho, Nevada, Oregon, Utah and Wyoming.
831 Pacific Slope Basins in California.

Topographic Maps:

Branch Mountain, Advance Sheet.
Goleta Quadrangle, Santa Barbara Co.
Jackson Quadrangle, Calif.
Newman Quadrangle.
Plan and Profile of Kings River, Piedra to Mile 32, California. North Fork to Balch Camp, Big Creek to Mile 4. Reservoir and Dam Sites, 6 sheets.
Plan and Profile of Putah Creek, from a point 2 miles above Winters to Middletown, Calif. Dam sites—6 sheets scale 1:31680.
Sequoia and General Grant National Parks, Calif.
Tobias Peak, Advance Sheet.

Bulletin:

895 D Geophysical Abstracts 91, October-December, 1937.

U. S. Bureau of Mines:

Information Circulars:

6990 Mining and Milling Methods and Costs at the Summitville Consolidated Mines, Inc., Summitville, Colo. By Jos. R. Guiteras.
7028 Reconnaissance of Placer Mining in Boise County, Idaho. By O. H. Metzger.
7029 Cost of Mining 55 Tons of Copper-Nickel Ore at the Great Eastern Prospect, Bunkerville, Clark County, Nev. By Paul T. Allsman.
7030 List of Respiratory Protective Devices approved by the Bureau of Mines. By H. H. Schrenk.
7031 Natural-Gasoline Plants in the United States, January 1, 1938. By G. R. Hopkins and E. M. Seeley.
7032 Some Observations on Coal-Mine Fans and Coal-Mine Ventilation. By D. Harrington and E. H. Denny.
7034 Petroleum Refineries, Including Cracking Plants, in the United States, Jan. 1, 1938. By G. R. Hopkins and E. W. Cochrane.
7035 Lighting Practices in Coal Mines of the United States. By A. B. Hooker and C. W. Owings.
7036 Necessity for More Extended Use of Safety Equipment in Mining. By D. Harrington.
7037 Some Instruments and Devices That Coal-Mine Officials Should Understand and Use. By G. W. Grove.
7038 A Study of Explosive Accidents Reported to the National Safety Competition, 1925-35.

Reports of Investigations:

3406 Progress Reports—Metallurgical Division, 23. Electrometallurgical Investigations. Electrolytic Manganese. By S. M. Shelton, M. B. Broyer, and A. P. Towne.
Boulder City, Nev., Electrometallurgical Laboratory. By J. Koster and R. G. Knickerbocker.
Pullman, Wash., Unit, Electrometallurgical Section. By H. A. Doerner.
3409 Ball-Mill Grindability Indexes of Some American Coals. By H. F. Yancey and M. R. Geer.
3410 Porosity of the Sundance Sand in the Lance Creek Oil Field, Wyoming. By H. Dale Nichols.
3411 Tests of a Barrier Using Rock Dust in Paper Bags. By H. P. Greenwald and H. C. Howarth.
3412 Ventilation of Manholes: 3. Effect of Wind Velocity on Natural Ventilation. G. W. Jones, E. S. Baker and John Campbell.
3413 National Safety Competition of 1937. By W. W. Adams, T. D. Lawrence, and E. E. Getzin.
3414 Production of Explosives in the United States During the Calendar Year, 1937. By W. W. Adams and V. E. Wrenn.
3416 Truck vs. Rail Haulage in Bituminous-Coal Strip Mines. By Albert L. Toenges and Frank A. Jones.

3417 Survey of Crude Oil in Storage 1936-1937. By Petroleum Economics Division and Petroleum and Natural Gas Division, Bureau of Mines.
3418 Consumption of Primary and Secondary Tin in the United States in 1936 and 1937. By John B. Umhau and M. E. Trought.
3419 Progress Reports—Metallurgical Division. 25. Annual Report of the Metallurgical Division, Fiscal Year 1937-38. By R. S. Dean and others.
3420 Mineral Economics Series. 3. Consumption of Ferrous Scrap and Pig Iron in the United States in 1937. By Robert H. Ridgway, H. W. Davis, and M. E. Trought.
3421 Active List of Permissible Explosives and Blasting Devices Approved Prior to June 30, 1938.
3422 Desalting Crude Petroleum. A Review of the Literature. By L. F. Christianson and Joseph W. Horne.

Bulletins:

405 Copper Mining in North America.
413 Mineral Industries Survey of the U. S., California, Calaveras County, Mother Lode District (South) Mines of the Southern Mother Lode Region, Part I, Calaveras County.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers. New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.

Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

Books:

American Men of Science—A Biographical Directory, 1938.
The Official Manual of the Cripple Creek District, Colorado. Published by Fred Hills; Donated by R. K. Hutchings, M.D.

John Hays Hammond Library:

Historic Spots in California, Counties of the Coast Range, by Mildred Brooke Hoover.
Historic Spots in California, the Southern Counties, by Hero Eugene Rensch and Ethel Grace Rensch.
Quartz Family Minerals, by H. C. Dake and Ben Hur Wilson.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of California Journal of Mines and Geology, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of California Journal of Mines and Geology.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

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REPORTS

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	$0.75
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	.75
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps William Irelan, Jr.	1.50
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.75
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176, pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.75
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	.75
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper	$1.00
Mines and Mineral Resources of Plumas County, 188 pp., paper	.75
Mines and Mineral Resources of Sierra County, 144 pp., paper	.75
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	2.50
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, ** November, December, 1922	.40
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	.40
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy	.40
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.40
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.40
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California, Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.40
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.40
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.40
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.40
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County	.40
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.40
April, 1928, Mines and Mineral Resources of Mariposa County	.40
July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	.40

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	$0.40
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
**January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	----
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.40
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.40
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.40
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	.40
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
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Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)	.25
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PRELIMINARY REPORTS

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**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin, 4 pp.	----
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**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

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**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----

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**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper	----
Bulletin. Reconnaisance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper	$0.25
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**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.30
**Register of Oil Wells, with Map, Los Angeles City (1906)	----

OTHER MAPS

**Map of California, Showing Mineral Deposits (50x60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Fortsts	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.25
**Map of Copper Deposits in California	----
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
**Geographical Map of Inyo County. Scale 1 inch equals 4 miles	----
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----

OTHER MAPS—Continued

	Price Postpaid
Geologic Map of California, 1916. Scale 1 inch equals 12 miles. Shows railroads, highways, post offices and other towns. Geological details lithographed in 23 colors. Mounted	$2.75
**Unmounted	----
Geologic Map of California, 1938. Scale 8 miles per inch. Lithographed in 80 distinguishing colors and patterns showing geologic units. In 6 sections, each 32 in. x 42 in. Set of 6 sheets, unmounted	4.00
Sheets not sold separately.	
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92. In 4 colors (also sold singly)	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly)	40
Map of Northern California, showing rivers and creeks which produced placer gold in 1932	.25
Mother Lode Geologic and claim maps in 5 county sections: El Dorado, Amador, Calaveras, Tuolumne and Mariposa. Single sections .25c. Set of 5	1.00
Map of Mariposa County, showing principal gold mines	.25
Geologic Map of Elizabeth Lake Quadrangle, Los Angeles and Kern Counties (accompanying October Chapter of Report XXX), sold separately	.25
Map of Western Portion of Siskiyou County Showing Location of Principal Gold Mines (accompanying July Chapter of Report XXXI), sold separately	.25
Geologic Map of Redding and Weaverville Quadrangles Showing Location of Gold Mines	.25
Map of Ancient Channel System, Calaveras County	.25
Map of Ancient Channels Between San Andreas and Mokelumne Hill	.25

OIL FIELD MAPS

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 1—Sargent, Santa Clara County	$0.75
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	1.25
Map No. 3—Santa Maria, including Casmalia and Lompoc	1.25
Map No. 4—Brea Olinda and (East Portion) Coyote Hills, Los Angeles and Orange Counties	1.25
Map No. 6—Salt Lake-Beverly Hills, Los Angeles County	1.25
Map No. 7—Sunset and San Emidio, Kern County	1.25
Map No. 8—South Midway and Buena Vista Hills, Kern County	1.25
Map No. 9—North Midway and McKittrick, Kern County	1.25
Map No. 10—Belridge and McKittrick Front, Kern County	1.25
Map No. 11—Lost Hills and North Belridge, Kern County	1.25
Map No. 12—Devils Den, Kern County	1.00
Map No. 13—Kern River, Kern County	1.00
Map No. 14—Coalinga, Fresno County	1.50
Map No. 15—Elk Hills, Kern County	1.25
Map No. 16—Ventura-Ojai, Ventura County	1.25
Map No. 17—Santa Paula-Sespe, including Bardsdale, South Mountain and Camarillo, Ventura County	1.25
Map No. 18—Piru-Simi-Newhall, Ventura County	1.25
Map No. 19—Arroyo Grande, San Luis Obispo County	1.00
Map No. 20—Long Beach, Los Angeles County	1.75
Map No. 21-B—Portion of District No. 5, showing boundaries of oil fields—Fresno, Kings and Kern Counties	1.00
Map No. 21-C—Portion of District No. 4, showing boundaries of oil fields—Kern, Kings and Tulare Counties	1.25

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 22—Portion of District No. 3, showing boundaries of oil fields—Santa Barbara County	$0.75
Map No. 23—Portion of District No. 2, showing boundaries of oil fields—Ventura County	1.00
Map No. 24—Portion of District No. 1, showing boundaries of oil fields—Los Angeles and Orange Counties	1.00
Map No. 26—Huntington Beach, Orange County	1.50
Map No. 27—Santa Fe Springs, Los Angeles County	1.25
Map No. 28—Torrance, Los Angeles County	1.25
Map No. 29—Dominguez, Los Angeles County	1.00
Map No. 30—Rosecrans, Los Angeles County	1.25
Map No. 31—Inglewood, Los Angeles County	1.25
Map No. 32—Seal Beach, Los Angeles and Orange Counties	1.25
Map No. 33—Rincon, Ventura County	1.50
Map No. 34—Mt. Poso, Kern County	1.00
Map No. 35—Round Mountain, Kern County	1.00
Map No. 36—Kettleman Hills, Fresno, Kings and Kern Counties	1.50
Map No. 37—Montebello, Los Angeles County	1.00
Map No. 38—Whittier, Los Angeles County	1.25
Map No. 39—West Coyote, Los Angeles and Orange Counties	1.25
Map No. 40—Elwood, Santa Barbara County	1.25
Map No. 41—Potrero, Los Angeles County	1.00
Map No. 42—Playa del Rey, Los Angeles County	1.50
Map No. 43—Capitan, Santa Barbara County	1.00
Map No. 44—Mesa, Santa Barbara County	1.50
Map No. 45—Buttonwillow gas, Kern County	1.00
Map No. 46—Richfield, Orange County	1.25
Map No. 48—Mountain View and Edison, Kern County	1.25
Map No. 49—Fruitvale, Kern County	1.00
Map No. 50—Wilmington, Los Angeles County	1.25
Map No. 51—Santa Maria Valley, Santa Barbara County	1.00
Map No. 52—El Segundo and Lawndale, Los Angeles County	1.50
Map No. 53—Rio Bravo, Greeley, Ten Section and Canal, Kern County	1.25

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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Jan. 1938

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, DIRECTOR
DIVISION OF MINES
WALTER W. BRADLEY STATE MINERALOGIST
PLATE III
LIST OF MINES
U. S. MINERAL MONUMENTS
MAP OF
INYO COUNTY
CALIFORNIA
SHOWING LOCATION OF
PRINCIPAL MINES
ACCOMPANYING REPORT ON MINES AND
MINERAL RESOURCES OF INYO COUNTY
BY W. B. TUCKER AND R. J. SAMPSON
1938
SCALE
5 10 15 MILES
• 250 MINES
◦ 62 U.S. MINERAL MONUMENTS
STATE OF NEVADA
DEATH VALLEY NATIONAL MONUMENT
INYO NATIONAL FOREST
FRESNO COUNTY
TULARE COUNTY
KERN COUNTY
SAN BERNARDINO COUNTY
MONO CO.
ESMERALDA CO.
NYE CO.
LINCOLN CO.
SIERRA NEVADA MTS
OWENS LAKE
BISHOP
BIG PINE
INDEPENDENCE
LONE PINE
KEELER
DARWIN
SHOSHONE
TECOPA
ZABRISKIE
2nd Standard Parallel South
3rd Standard Parallel South
4th Standard Parallel South
5th Standard Parallel South
6th Standard Parallel South
ACCOMPANYING STATE MINERALOGIST'S REPORT XXXIV. OCTOBER 1938.